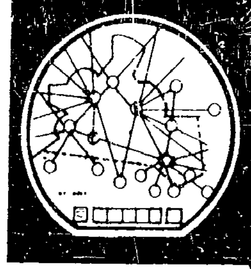
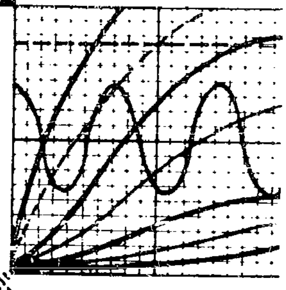
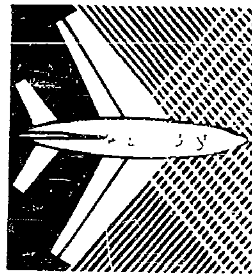




FINAL REPORT

Task No. 101-112V



DYNAMIC SIMULATION STUDY AND EVALUATION OF A PROPOSED AIR TRAFFIC PROCEDURAL PLAN & CONTROL EQUIPMENT CONFIGURATION FOR THE WASHINGTON, D.C., AREA

MARCH 1962

FEDERAL AVIATION AGENCY
Aviation Research & Development Service
EVALUATION DIVISION
Atlantic City, New Jersey

United State Government
MEMORANDUM

FEDERAL AVIATION AGENCY

Date: May 4, 1962

SUBJECT: Transmittal of Final Report on Project No. 101-112V, "Dynamic Simulation Study and Evaluation of a Proposed Air Traffic Procedure Plan and Control Equipment Configuration for the Washington, D. C. Area"

FROM : Chief, Evaluation Division

TO : Director, Aviation Research and Development Service, RD-1

A final report is forwarded herewith to reflect the results of Project Assignment No. 101-112V, entitled "Dynamic Simulation Study and Evaluation of a Proposed Air Traffic Procedure Plan and Control Equipment Configuration for the Washington, D. C. Area".

Authority to proceed with this work was assigned to the Test and Experimentation Division on November 24, 1961, as Task Assignment No. 101-112T, and was reassigned to the Evaluation Division following the December 1961 reorganization of the Aviation Research and Development Service.

N. O. Hannaman

for Aldro Lingard, RD-50

FINAL REPORT

DYNAMIC SIMULATION STUDY AND EVALUATION OF A PROPOSED AIR TRAFFIC PROCEDURAL PLAN AND CONTROL EQUIPMENT CONFIGURATION FOR THE WASHINGTON, D. C., AREA

PROJECT NO. 101-112V

Prepared by:

D. Bottomley
R. E. Hansen
T. R. Johnson
H. T. Rohland
S. E. Rossiter
E. H. Wright

March 1962

This report has been approved.

N. U. Hermansen
for Aldro Lingard
Chief, Evaluation Division

FEDERAL AVIATION AGENCY
Aviation Research and Development Service
Evaluation Division
National Aviation Facilities Experimental Center
Atlantic City, New Jersey

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DYNAMIC SIMULATION STUDY AND EVALUATION OF A PROPOSED AIR TRAFFIC PROCEDURAL PLAN AND CONTROL-EQUIPMENT CONFIGURATION FOR THE WASHINGTON, D. C. AREA BY
D. Bottomley, R. E. Hansen, T. R. Johnson, H. T. Rohland, S. B. Rossiter, E. H. Wright, March 1962, 146 pp. incl. 57 illus.
Final Report (Project No. 101-112V)

ABSTRACT

The purpose of this project was to conduct a simulation study and evaluation of a proposed procedural plan for the operation and control of instrument flight rule (IFR) air traffic in the Washington D. C. area. An optimum procedural plan was developed by simulation and modification of the proposed plan; this plan was then tested with three different IFR control-room equipment configurations.

The first of the equipment tests utilized a terminal area IFR room configuration proposed for location in Hangar 6 at Washington National Airport in the space presently occupied by the Air Route Traffic Control Center. Two other configurations were tested which integrated terminal control with en route control, one an "In-Line" and the other a "Butterfly" equipment arrangement. The two integrated configurations were proposed for installation in the new Center building at Leesburg, Va.

The modified procedural plan functioned properly with the traffic density simulated under all three equipment configurations, with approximately the same number of aircraft movements. Overall coordination was easier and controller workload was less under the "Butterfly" configuration. Separate tests were made of Andrews Air Force Base IFR and VFR traffic with increased density. No difficulties were encountered in the tests. En route tests were conducted to determine what problems existed in that area, but none was apparent.

PURPOSE

The purpose of this project was to study and evaluate a proposed procedural air traffic plan and to test it, or a modification thereof, against three control-equipment configurations. The Washington, D. C., metropolitan or "Metroplex" area was simulated.

SUMMARY

The Model B dynamic air traffic control simulator was the primary tool used in this project. The proposed procedural plan was modified and tested against three different IFR room configurations. No attempt was made to segregate IFR control functions or to test the system presently in use.

INTRODUCTION

The Eastern Region through the Air Traffic Service (ATS) requested that the Washington metropolitan area, or Metroplex be simulated to study, evaluate and modify a proposed terminal area procedural plan. The plan encompassed Washington National, Dulles International and Andrews Air Force Base Airports. In addition, a request was made to test the modified procedural plan under three proposed control-equipment configurations. The three configurations proposed were "Hangar 6," which was a common approach control or RAPCON-type IFR room located at Washington National Airport, "In-Line," and a "Butterfly" configuration, the latter two being located in, and integrated with, the Air Route Traffic Control Center (ARTCC) at Leesburg, Va. On August 16, 1961, a meeting was held in the Washington ARTCC conference room to establish assumptions and objectives for the simulation.

Objectives

The objectives established were to:

1. Test and modify, as necessary, a proposed Metroplex procedural plan for the Washington, D. C. area.

2. Utilizing the modified procedural plan, test and modify three equipment configurations: (a) Hangar 6, (b) In-Line, and (c) Butterfly.

Assumptions

The following assumptions were made:

1. A complete radar environment would exist in the Washington, D. C. area.

2. Adequate communications would be available.

3. Only IFR traffic at Washington, Dulles and Andrews Airports would be simulated.

4. The holding airspace areas would be in accordance with ATM Circular No. 50 "Determination of Aircraft Holding Pattern Airspace," dated June 6, 1961.

5. Airport runway acceptance rates would not limit system capability.

6. Baltimore Airport would be considered a separate entity and would not be pertinent to the dynamic simulation.

7. The Washington ARTCC would have the capability of accepting all departures generated by the terminal area.

8. The Washington ARTCC would have the capability of metering arrival traffic to comply with the demands of the terminal area.

9. Compliance with ATM Circular No. 44, "Arrival Radar Identification Monitoring and Handoff," dated May 2, 1961.

10. Traffic samples would reflect forecast densities through February 1964.

Prior to the dynamic simulation, an Eastern Region Facility planning team came to the National Aviation Facilities Experimental Center (NAFEC), and worked with the evaluation team for several weeks. The planning team included representation from the Eastern Regional Office, the Washington ARTCC, Washington National Tower, and Department of the Air Force. During this time, changes were made in the procedural plan and operating rules were established for this simulation. Control room diagrams were revised for the three proposed configurations. The dynamic simulation schedule was flexible to accommodate the evolutionary changes which arose during simulation. The Franklin Institute Laboratories (FIL), Philadelphia, Pa., participated in the test design and data analysis.

The dynamic simulation started on October 9, 1961, and was completed on December 8, 1961. A total of 20,000 simulated aircraft were controlled during the 140 dynamic simulation test runs. The original procedural plan submitted by the Eastern Region was simulated in Phase I. Phase II was formulated as a result of four major changes to the original procedural plan.

SIMULATION TECHNIQUES

Simulation Plan

In an effort to test and modify the proposed procedural plan, the planning group decided the simulation would be programmed in the following manner:

1. A three-week period at the outset of the dynamic simulation would be devoted to testing and modifying all facets of the procedural plan.

2. Two weeks would be set aside for each equipment configuration. The nondata runs made during the first few days would be utilitarian, to become familiar with position duties as related to the configuration, and the remainder of the time would be devoted to data runs.

3. A total of 12 data runs would be made for each equipment configuration.

Simulation Equipment

The Model B dynamic air traffic control (ATC) simulator, consisting of 60 pilot consoles, associated radar displays, flight data boards and communications equipment, was used for this simulation. Each of the pilot consoles (radar target generators), as shown in Fig. 1, provided realistic performance of the aircraft types selected. Some of the preset aircraft types and parameters simulated are shown in Table I.

Three TI-440 scan converters were used in conjunction with the Model B simulator to provide bright-tube radar displays on 22-inch horizontal and 20-inch slant scopes, as shown in Fig. 2. The characteristics of ASR-4 and ARSR-1 radar were simulated. A limited area of nonradar return existed at all altitudes within a radius of approximately 2 miles of the simulated radar antenna sites. This limitation necessitated the relocation of the present radar sites for this simulation study only. Each pilot console was equipped with a 24-channel communication capability which provided a discrete channel for each controller.

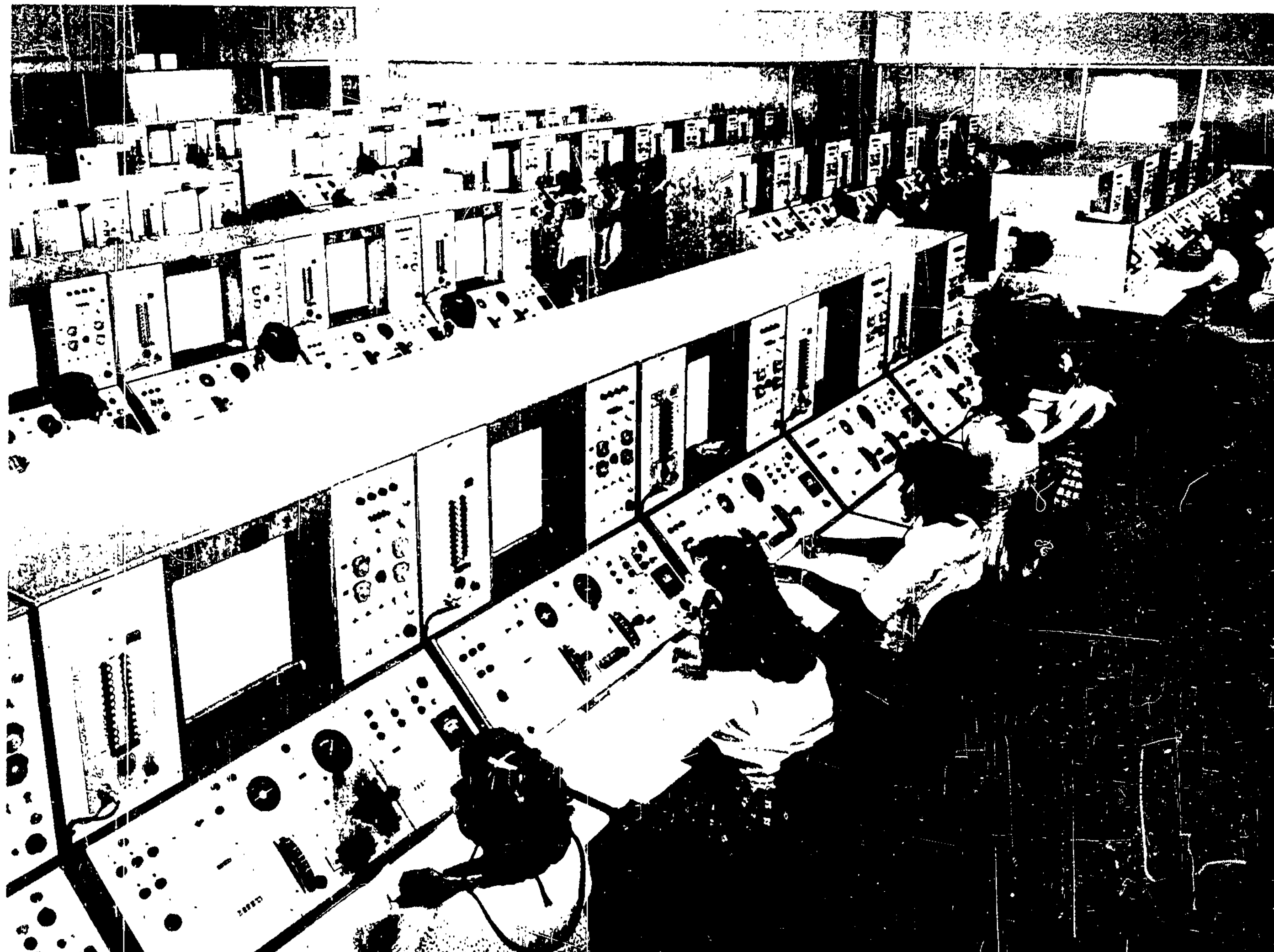


FIG. 1 RADAR TARGET GENERATORS

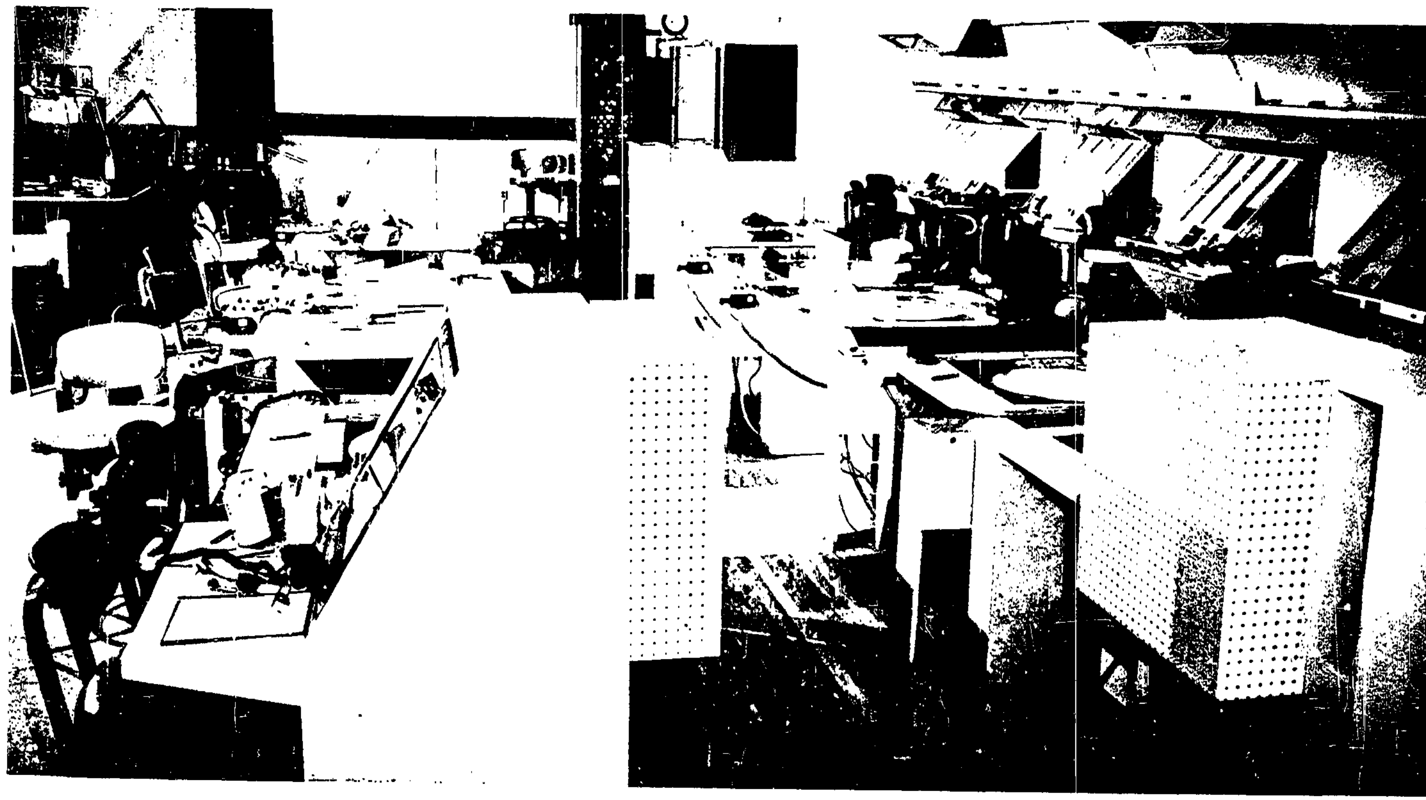


FIG. 2 SCAN CONVERTERS AND SLANT SCOPE

Seventeen interphone lines were available, some of which were used in lieu of "hot lines." In addition, six intercom lines were provided for inter- and intra-facility coordination.

TABLE I

TYPES OF AIRCRAFT AND PARAMETERS SIMULATED

Aircraft Type Switch Position	Aircraft Type	Max. Turn Rate (deg/sec)	Normal Turn Rate (deg/sec)	Max. Climb Rate (ft/min)	Normal Climb Rate (ft/min)	Max. Descent Rate (ft/sec)	Normal Descent Rate (ft/sec.)
1.	DC-3	4.5	3	800	500	800	500
2.	DC-4	4.5	3	800	500	800	500
3.	Boeing 377	4.5	3	1,200	600	2,500	1,000
4.	Convair 340	4.5	3	1,100	900	1,500	1,000
5.	Constellation L-749	4.5	3	1,100	900	2,500	1,000
6.	DC-6	4.5	3	1,100	800	2,000	1,000
7.	Viscount	3	1.5	2,000	1,500	2,500	1,500
8.	DC-7	4	3	1,100	900	2,500	1,000
9.	Electra	3	1.5	2,500	1,500	4,000	2,500
10.	Boeing 707	3	1.5	3,000	2,000	6,000	3,000
11.	F-100A	4.5	1.5	20,000	9,500	10,000	3,500

Traffic Sample

From peak-day flight data supplied by the Washington ARTCC and Washington Approach Control facilities, a one-hour-and-15-minute traffic sample was prepared.

Dulles International Airport: Since Dulles Airport was under construction at the time of this evaluation, no actual traffic was available for study. Little information could be obtained regarding the types or volume of aircraft which would utilize the airport, other than that it was primarily a jet airport. At the exploratory meeting in Washington, between ATS and Aviation Research and Development Service (ARDS) personnel, it was agreed that a 60-per-hour aircraft movement, comprised of 75 per cent jet and 25 per cent conventional types, would approximate the anticipated activity.

1. Information obtained from the Washington ARTCC indicated that transoceanic aircraft from Europe would approach the area from the north-northwest. This traffic, in addition to the domestic traffic approaching from the northwest, was routed via Charles Town so this fugure was set at 60 per cent. The remaining 40 per cent was routed via Glen Ora with 60 per cent of this traffic approaching via V39 and 40 per cent via V174 (Fig. 3).

2. In programming departures, the major portion of the traffic departed to the north and northwest serving the European and Western airports. Thirty-three and one-half per cent departed westbound on V92, 33 1/2 per cent departed northbound on V223, and 33 per cent departed south and southwestbound on V223.

Washington National Airport: The peak hour at the Washington Airport was 59 aircraft movements, with a slightly higher number of departures than arrivals. Projected traffic forecast called for an increase in operations. Aircraft were added to reflect this increase in arrivals, as arrivals posed more problems to the controller. Consequently, there were 36 programmed arrivals and 30 departures per hour.

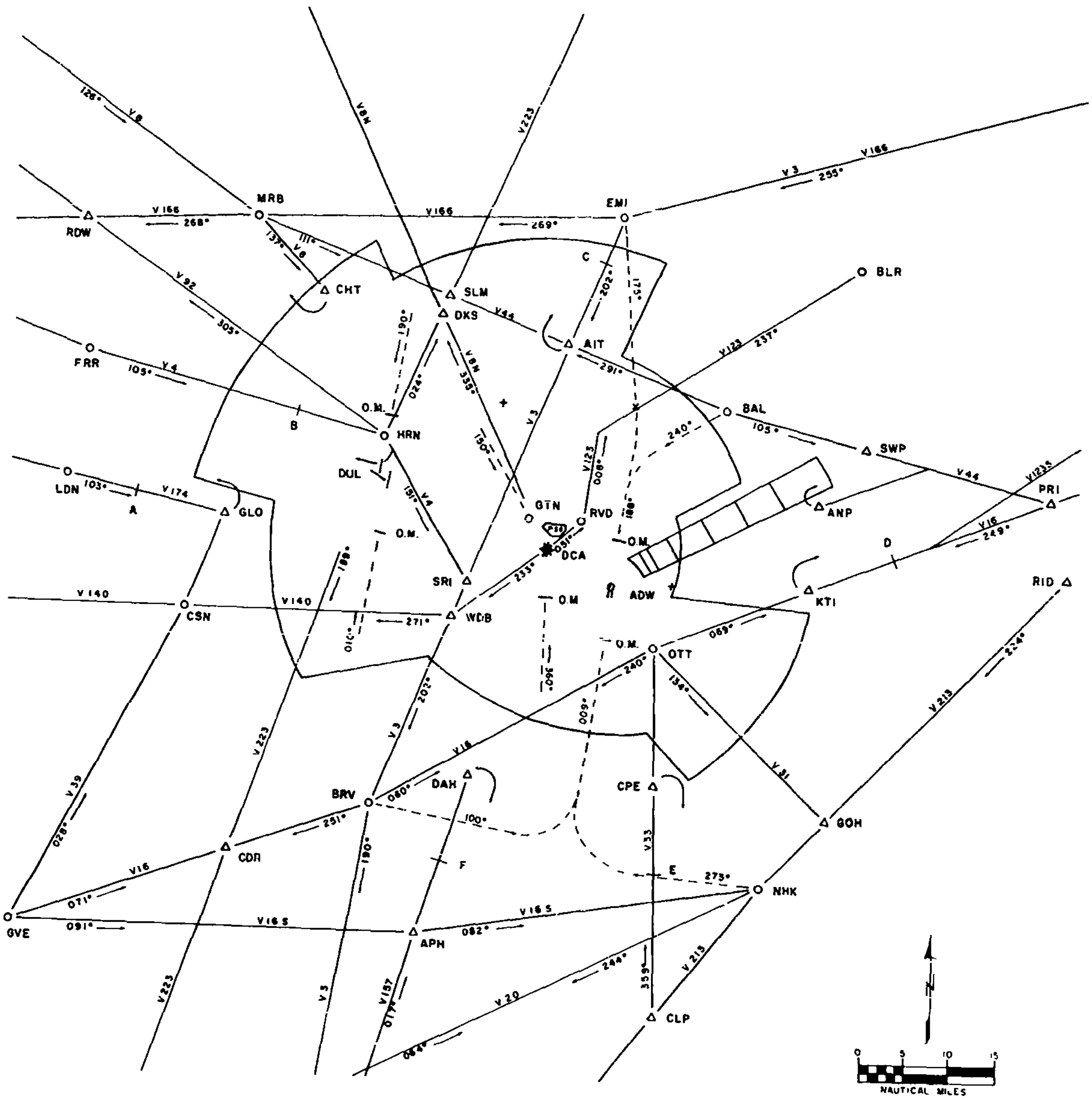


FIG. 3 PROPOSED ROUTE STRUCTURE

1. Of the arrival traffic, 37 per cent arrived from the north via V3 to Gaithersburg, 16 per cent from the west via V4 to Herndon, 35 per cent from the south and southwest via V157 to Dahlgren, and 12 per cent from the northeast via V16 to Kent Island, or in the case of Phase II, to Annapolis.

2. Of the departures, 53 per cent departed to the north via V123 or V123S in Phase II on a south operation, 18 per cent to the northwest via V8N, 13 per cent to the south via V3, and 16 per cent to the southwest via V140.

Andrews AFB Airport: The traffic count for the peak ARTCC day was comparatively light at Andrews; therefore it was necessary to add additional flights to increase the level of activity to the desired amount. Information received from the Andrews AFB representative indicated that, for this simulation, 60 IFR aircraft movements per hour would portray the expected increase in activity attendant with the transfer of the Anacostia-Bolling field operations to Andrews. Of these 60 movements, approximately 75 per cent were jet-type and 25 per cent conventional-type aircraft.

1. The jets were evenly distributed for penetrations between the Patuxent River and Brooke VOR facilities during a north operation. When landing south, all jets penetrated from the Baltimore VOR facility.

2. Of the conventional aircraft, 33 per cent arrived from the south via V33 to Chesapeake, 33 per cent from the northeast via V16 to Kent Island or Annapolis, 20 per cent from the west via V4 to Herndon, and 14 per cent from the north and northwest via V3 to Gaithersburg.

Because of the large number of flights to be generated during this problem, and in an effort to achieve maximum target generator availability, the aircraft were started and terminated in the following manner:

1. Arrival aircraft started in the problem at the lettered start points (Fig. 3), Martinsburg and Casanova, and terminated flight at the outer marker(s)

and/or the Georgetown radio beacon on final. Flight was terminated at these points because, in addition to the reason mentioned earlier, no effort was made to test the runway acceptance rate for any of these airports.

2. Departure aircraft terminated flight upon passing the peripheral stop line, which was a continuous series of arcs drawn on the pilot map (Fig. 3). This line was drawn on the premise that, when an aircraft reached this point, all conflictions would have been properly resolved.

3. Jet arrival traffic for Andrews AFB started over the Baltimore VOR in a south operation and over the Patuxent River or Brooke VOR's on a north operation.

Area

The area covered by the dynamic simulation of the Washington Metroplex was 120 by 120 nautical miles, with the geographical center located at the Washington Airport. The airways depicted represented the low-altitude route structure. The three airport operations simulated were Washington, Dulles, and Andrews AFB Airports.

Measurements

Communications data were recorded during each data run of the dynamic simulation as related to each equipment configuration and phase. Each radio communication channel used during the simulation was recorded on an electronic multichannel communication counter. The counter measured the total number of radio contacts as well as the overall time spent on the frequency by the controller. This information was recorded in 15-minute increments.

The simulator pilots completed data sheets for each of the assigned flights, (see Figs.4 and 5). Information recorded in this manner gave a complete history of each flight. Statistical results were compiled from these data sheets. Some of the important items recorded were as follows:

1. Clearance issued by the controller.

2. Number of radar vectors.

3. Number of altitude changes.

4. Departure time.

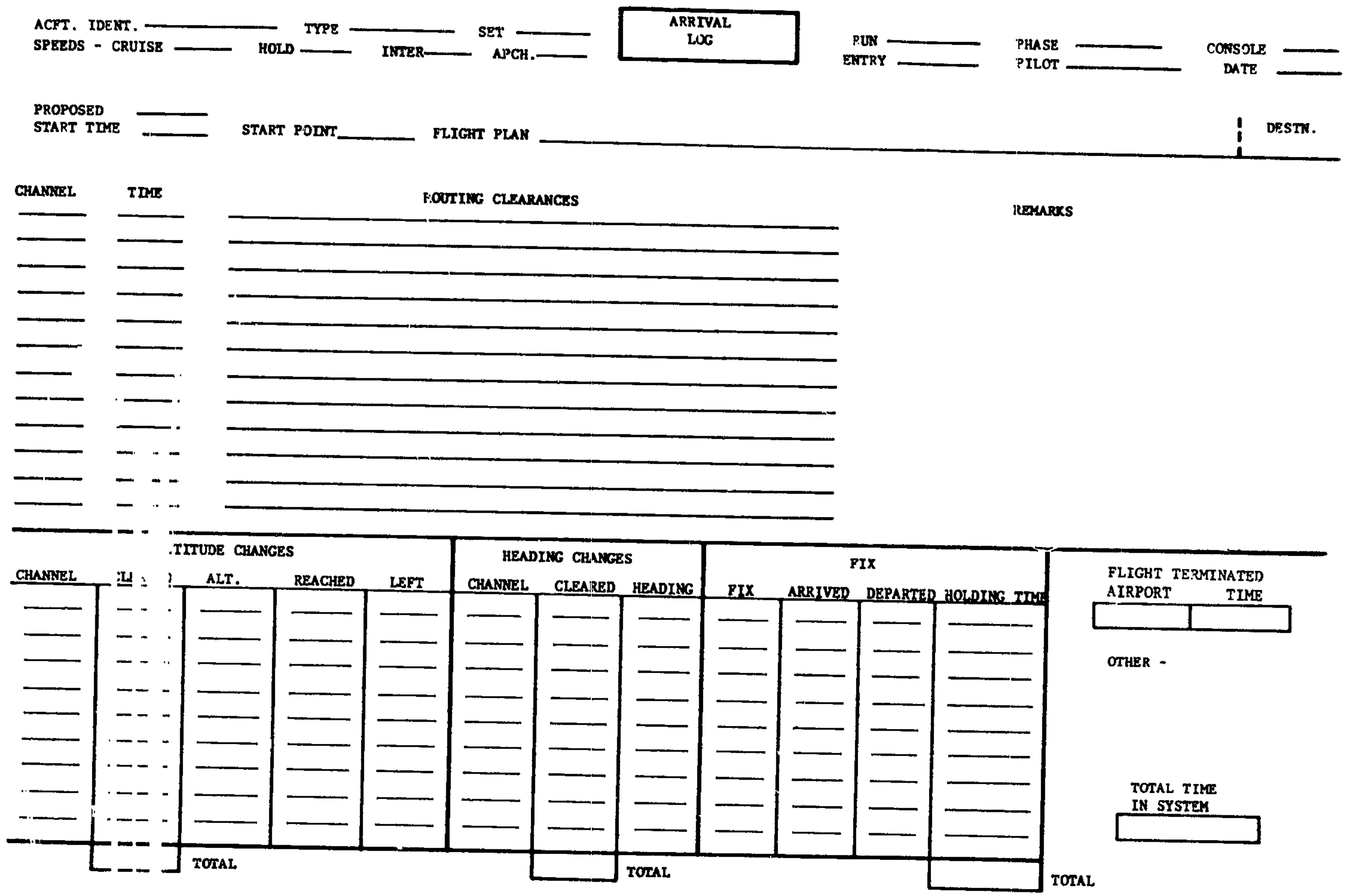
5. Arrival time over final approach fix.

6. Holding time at fixes.

7. Total flight time.

Two types of controller questionnaires were prepared (see Appendices IV and V). These questionnaires were prepared in order to record controller opinion on various operational facets of the Washington simulation. Appendix IV is a rating-scale questionnaire in which the controller indicated his opinion as to whether a particular operation was difficult, easy, or somewhere in between, by selecting a figure between 1 and 7; 1 was the easiest, and 7 the most difficult. This questionnaire was filled out by all controllers at the end of each data run. Appendix V is a narrative-type questionnaire in which the controller expressed his opinion regarding various operations, and was completed by controllers after several runs of the same type.

During the test studies, controller critiques were held, on a random basis, under the guidance of various NAFEC team members. These critiques provided an opportunity for the controllers to express opinions and recommendations on any facet of the dynamic simulation; portions of this report will reflect some of these thoughts.


ACFT. IDENT. ______ TYPE ______ SET ______
SPEEDS - CRUISE ______ HOLD ______ INTER ______ APCH. ______

ARRIVAL LOG

RUN ______ PHASE ______ CONSOLE ______
ENTRY ______ PILOT ______ DATE ______

PROPOSED START TIME ______ START POINT ______ FLIGHT PLAN ______ DESTN.

CHANNEL	TIME	ROUTING CLEARANCES	REMARKS

ALTITUDE CHANGES					HEADING CHANGES			FIX			
CHANNEL	CLEARED	ALT.	REACHED	LEFT	CHANNEL	CLEARED	HEADING	FIX	ARRIVED	DEPARTED	HOLDING TIME
	TOTAL					TOTAL					TOTAL

FLIGHT TERMINATED
AIRPORT TIME

OTHER -

TOTAL TIME IN SYSTEM

FIG. 4 PILOT ARRIVAL DATA SHEET

ACFT. IDENT. ______ TYPE ______ SET ______ **DEPARTURE LOG** RUN ______ PHASE ______ CONSOLE ______

SPEEDS-CLIMB ______ INTER ______ CRUISE ______ ENTRY ______ PILOT ______ DATE ______

(Time)

P ______

R ______

FLIGHT PLAN - A ______

TOTAL DELAY (A-R) ______

(Alt.)

P ______

A ______

DPTR. POINT | ROUTING | DESTN

CHANNEL	TIME	ROUTING CLEARANCES	REMARKS

ALTITUDE CHANGES					HEADING CHANGES			FIX			
CHANNEL	CLEARED	ALT.	REACHED	LEFT	CHANNEL	CLEARED	HEADING	FIX	ARRIVED	DEPARTED	HOLDING TIME
	TOTAL					TOTAL					TOTAL

FLIGHT TERMINATED

FIX	TIME

OTHER -

TOTAL TIME IN SYSTEM

FIG. 5 PILOT DEPARTURE DATA SHEET

OPERATING PROCEDURES AND PROCEDURAL PLAN MODIFICATIONS

The following procedures reflect the evolution of modifications to the original procedural plan as received prior to the dynamic simulation. The preferential routes as specified in the Eastern Region plan were not changed during simulation. Arrival traffic at all clearance limits was provided separation by the Center.

Dulles Airport - Phase I - North Operation

Arrivals

Charles Town: Arrival traffic from the northwest via V8 to Charles Town: was started by the ARTCC at Martinsburg (see Fig. 6). Radar handoffs to the Charles Town transition controller were accomplished as soon as practicable after the aircraft left Martinsburg, and no later than Charles Town. The minimum acceptance altitude was 5000 feet. The Charles Town transition controller descended these aircraft so as to cross V92 at 3000 feet, to be under departure traffic. Coordination was effected with the Glen Ora transition controller and a proper sequence was established. On downwind leg west of the airport, aircraft were handed off to the final controller who continued vectors to the ILS final approach course. Some runs called for the transition controller to vector Dulles arrival traffic from Charles Town over the Herndon VOR and to the localizer course from the east side, in an effort to emulate East/West sectors. This resulted in greatly extended vector patterns and was not considered a desirable operation.

Glen Ora: Arrival traffic from the west on V174 was started by the ARTCC at Point "A" (see Fig. 6), and traffic approaching from the south on V39 was started at Casanova. Radar handoffs to the Glen Ora transition controller were accomplished as soon as practicable after these points, and in no case later than Glen Ora. The minimum acceptance altitude was 4000 feet. Due to the proximity of this fix to the outer marker (on north operations), the Glen Ora transition controller coordinated closely with the Charles Town transition controller to set up a sequence and then handed off to the final controller in the immediate vicinity of Glen Ora.

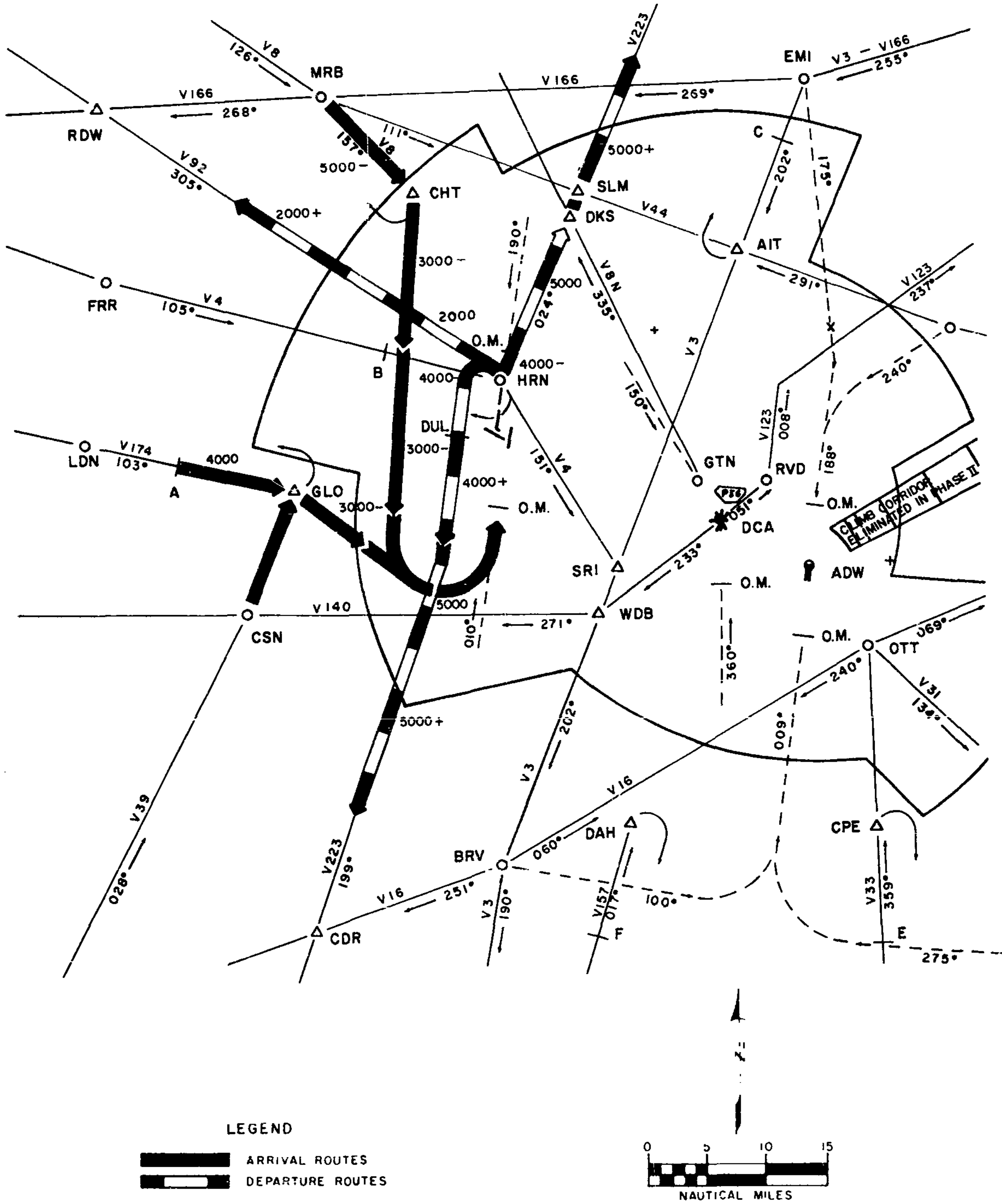


FIG. 6 DULLES ARRIVAL AND DEPARTURE ROUTES - NORTH OPERATION (PHASES I AND II)

Departures

Departures proceeding southbound on V223 were initially instructed to make a right turn after takeoff with vectors to intercept the airway. They maintained 4000 feet until south of V4, then 5000 feet until past V140 (Fig. 6). The restrictions provided separation from Washington/Andrews arrival traffic on V4 at Herndon and Washington/Andrews departure traffic which crossed V223 at or above 6000 feet. The Dulles departure controller normally deleted these restrictions through coordination with the controller(s) responsible for these areas.

When the Washington Airport was operationally south, a problem became evident from the right turns because the Washington transition arrival controller had to keep the V4 Herndon traffic at 5000 feet until approximately 5 miles east of the Herndon VOR. By then it was difficult to line up traffic inbound to Georgetown at 1500 feet without excessive path-stretching. This untenable situation was rectified by having southbound departures make left turns after takeoff. The left turns did not interfere with vectored traffic off Charles Town because the arrival aircraft were vectored to remain at least 8 miles west of the airport on downwind leg, and the departures completed turns within 4 miles of the airport. The procedural plan was modified to reflect this change.

Departures to the northwest via V92 made a left turn to intercept the airway and maintained 4000 feet until clear of the Herndon TSO (N-20a). This kept the aircraft below inbound traffic on V4. However, it posed a problem for vectored traffic off Charles Town being descended so as to enter V92 at or below 3000 feet. Two procedures were tried in an effort to resolve this situation:

1. Aircraft were advised to climb on runway heading to 3000 feet before proceeding on course. This resulted in a penalty to the aircraft, in both time and distance, plus an additional vector workload for the controller.

2. Aircraft were cleared on course and restricted to maintain 2000 feet until clear of the Herndon TSO. This restriction worked out nicely, as the departure controller effected coordination for further climb easily with both the transition controller

handling Charles Town traffic and the transition controller handling Herndon traffic. This departure procedure eliminated the need for vectoring V92 traffic and allowed for additional airspace for descending arrival traffic from over Charles Town. The procedural plan was altered to indicate this change.

Departure traffic northbound on V223 maintained 4000 feet until clear of the Herndon TSO because of Washington arrival traffic on V4, and then maintained 5000 feet until clear of V8N. The latter restriction provided separation from V8N departures out of Washington/Andrews which had been instructed to cross V223 at or above 6000 feet. Coordination with the Herndon transition controller and the controller handling the V8N departures deleted these restrictions as the situation dictated. During some runs, Dulles departure traffic tried crossing V140 (on a south operation) and V8N (on a north operation) above departure traffic out of Washington and Andrews. This was workable, but the related coordination was excessive.

Dulles Airport - Phase I - South Operation

Arrivals

Charles Town: Arrival traffic from the northwest via V8 to Charles Town was started by the ARTCC at Martinsburg, as in a north operation (Fig. 7). Radar handoffs to the Charles Town transition controller were accomplished as soon as practicable after the aircraft left Martinsburg, and in no case later than Charles Town. The minimum acceptance altitude was 3000 feet. The transition controller descended aircraft to available altitudes and issued headings to leave Charles Town, then effected handoffs to the final controller. The same close coordination, as exercised by the Glen Ora transition controller in a north operation, was mandatory for the Charles Town transition controller, due to the proximity of Charles Town to the ILS final approach course.

Glen Ora: Arrival traffic from the west on V174 and south on V39 was started by the ARTCC in the same manner as in a north operation. The Glen Ora transition controller received handoffs at the same points and descended the aircraft so as to cross V4 at or below 4000 feet and V92 at 3000 feet. The restriction at V4 provided separation from Herndon arrival traffic and the restriction at V92 provided separation from departure traffic. Coordination

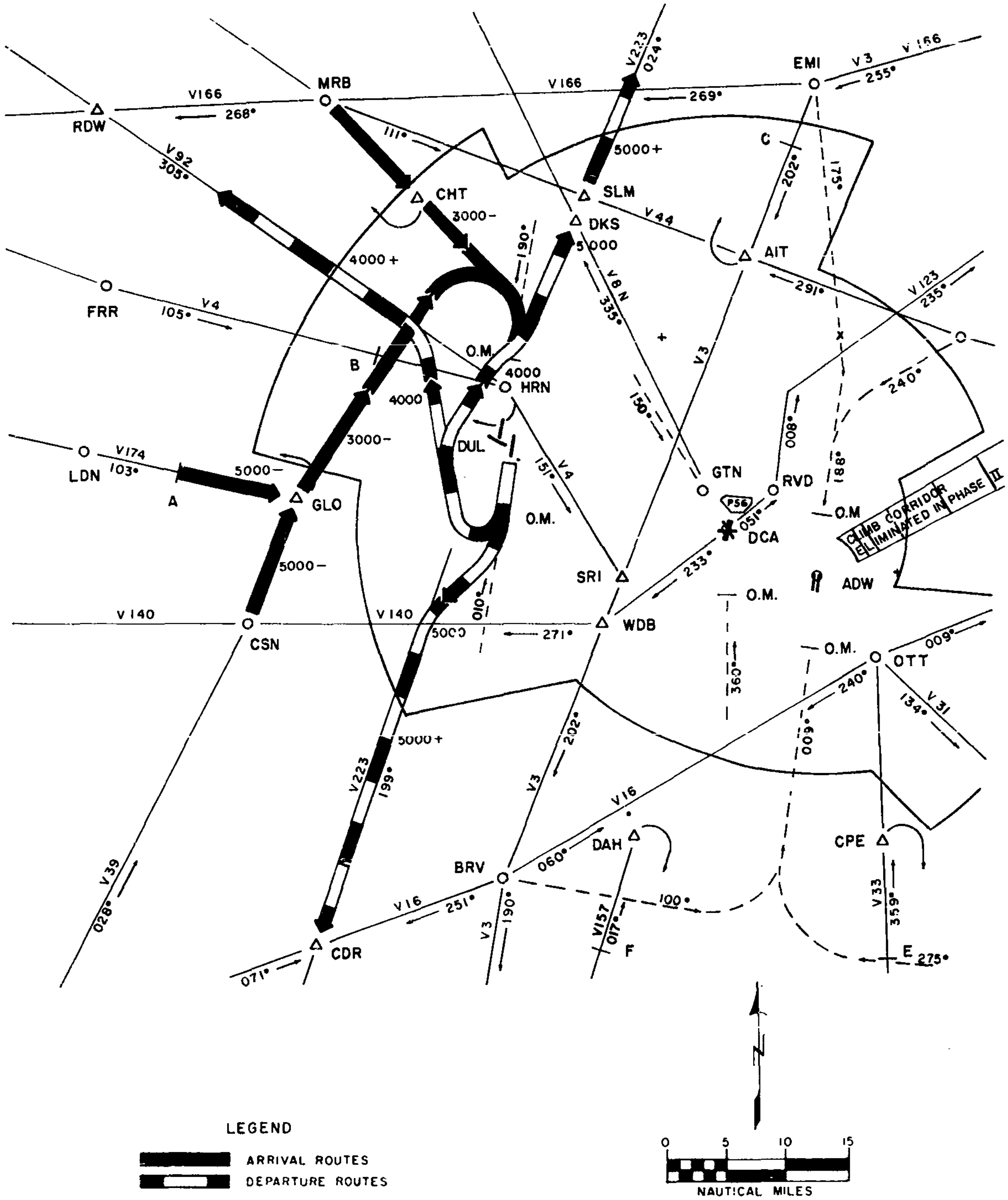


FIG. 7 DULLES ARRIVAL AND DEPARTURE ROUTES - SOUTH OPERATION (PHASES I AND II)

was effected with the Charles Town transition controller, and a sequence was established. Handoffs to the final controller were made crossing V4, or no later than when crossing V92.

Departures

Northbound departures on V223 and northwestbound departures on V92 made a left turn after takeoff (Fig. 7). Departures on V223 were restricted to 4000 feet until clear of the Herndon TSO to afford separation with Washington/Andrews arrival traffic at Herndon via V4, and to 5000 feet until past V8N to clear Washington/Andrews departures which were instructed to cross V223 at or above 6000 feet. Departures on V92 were restricted to 4000 feet until clear of the Herndon TSO, to clear the same V4 arrival traffic as enumerated above.

Left turns interfered with Washington/Andrews traffic in the same manner as right turns in a north operation with Washington operationally south. To alleviate this problem, it was decided to have Dulles departures proceeding north or northwest make a right turn after takeoff. Herndon traffic on V4 was decended immediately after passing the Herndon VOR, which afforded easier control of Washington/Andrews traffic. These right turns had no effect on vectored arrival traffic from Glen Ora, because the same procedures used in the north operation for clearing Charles Town vectored traffic were applicable. The procedural plan was modified to reflect this change.

Dulles Airport - Phase II

Operations at Dulles Airport were handled in exactly the same manner as in Phase I, due to the fact that the changes reflected in Phase II had no bearing whatsoever on Dulles traffic.

This phase evolved from the changes proposed to Phase I. These changes are listed below and reflect the difference between the two phases.

1. Deletion of the Andrews AFB climb corridor.

2. Deletion of the Kent Island Intersection as a clearance limit.

3. Addition of V123S.

a. The routing is a 109° radial of Andrews AFB VOR until intercepting the 069° radial of Nottingham VOR, proceeding outbound on that radial until intercepting the 235° radial of Woodstown VOR. This route would provide egress for traffic departing Washington/Andrews AFB destined for Newark and LaGuardia areas.

4. Addition of the Annapolis Intersection, which is comprised of the 248° radial of Churchill VOR and the 135° radial of the Baltimore VOR. This clearance limit replaced Kent Island and is clear of V123S.

Washington Airport - Phase I - North Operation

Arrivals

Gaithersburg: Arrival traffic from the north via V3 was started by the Center at Point "C" (Fig. 8). Minimum acceptance altitude was 5000 feet. Handoffs to the transition controller were accomplished as soon as practicable prior to the Gaithersburg clearance limit. The transition controller vectored these aircraft to downwind leg on the west side of the Washington Airport and east of V3. The aircraft maintained 5000 feet in order to remain above departure traffic on V140. When south of this departure route, the aircraft were given descent instructions and handed off to the final controller, who completed the vectors to the ILS final approach course. This method of operation created a situation wherein three of the four Washington feeder fixes (Gaithersburg, Herndon, and Dahlgren) were feeding the west side of the localizer. The 5000-foot restriction, until south of V140, resulted in an extended downwind leg for some aircraft in order to lose sufficient altitude for an approach. This extended downwind leg resulted in some aircraft being very close to the Dahlgren clearance limit, which created further congestion in this area and precluded a smooth flow of arrival traffic. To alleviate this situation, the Gaithersburg arrival traffic was rerouted to the east of Washington. The rerouting was accomplished by vectoring inbound traffic from Gaithersburg south on V3 to a point short of V8N, then over Riverdale to a heading of approximately 190° for downwind leg. After passing Riverdale, descent clearance was given and handoffs made to the final controller. This procedure allowed for an earlier descent and distributed more equably the Washington

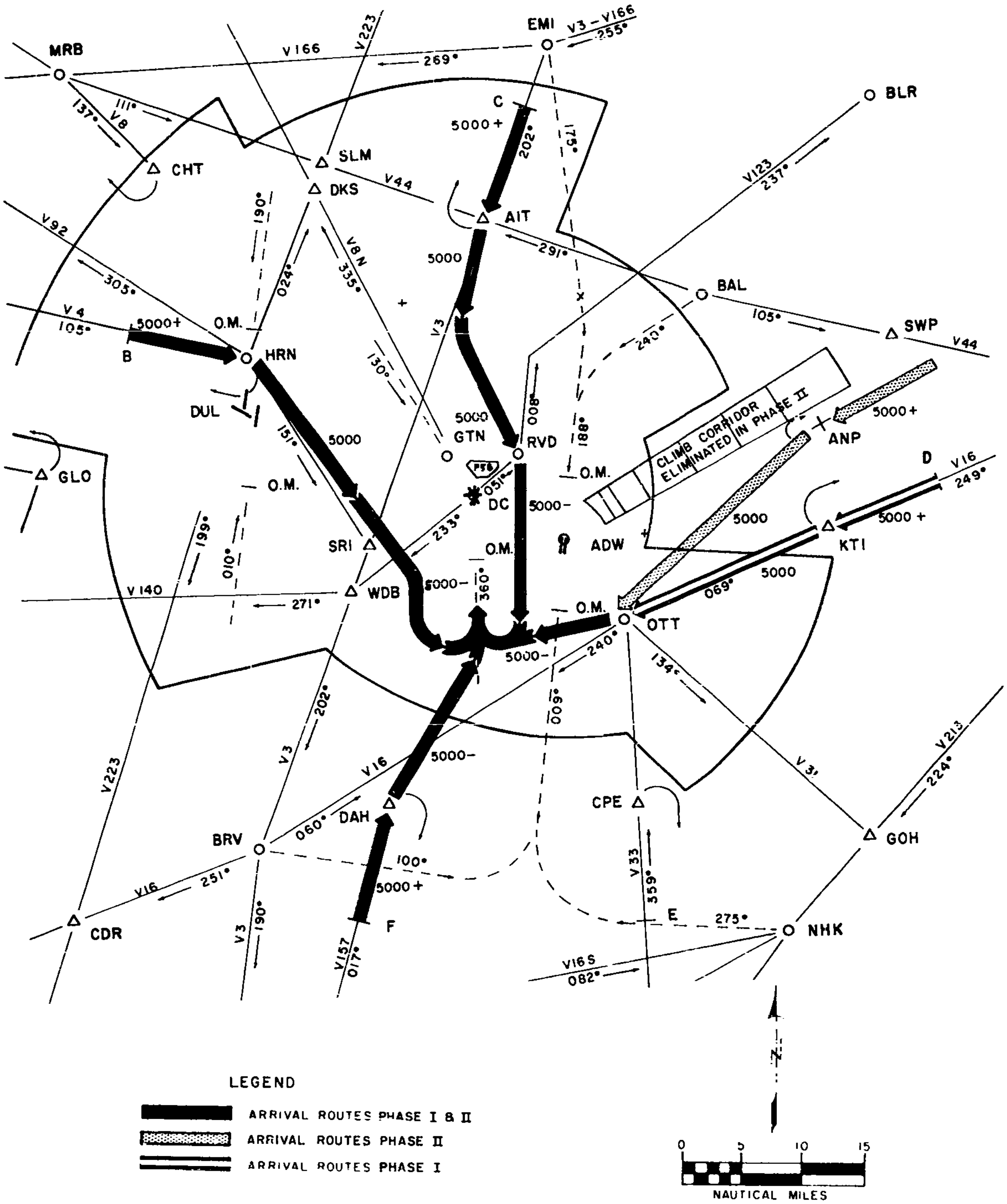


FIG. 8 WASHINGTON ARRIVAL ROUTES - NORTH OPERATION (PHASES I AND II)

arrivals on both sides of the localizer. A disadvantage to this routing was the limited amount of vectoring airspace available between Washington and Andrews Airports. This limitation meant that these aircraft should be in a properly spaced sequence at Riverdale.

Herndon: Arrivals from the west via V4 were started by the ARTCC at Point "B" (see Fig. 8). Minimum acceptance altitude was 5000 feet due to Dulles departure traffic. Handoffs to the transition controller were accomplished as soon as practicable prior to the Herndon clearance limit. The Herndon transition controller vectored this traffic on a heading of approximately 150° and effected handoffs to the final controller crossing V140. When the aircraft were clear of V140, descent instructions were given and the necessary vectors to the ILS final approach course completed. The same situation existed with the aircraft on downwind leg that was prevalent at Gaithersburg, being high abeam the outer marker due to the 5000-foot restriction. However, since traffic from Herndon was of a low density, the necessary coordination between the arrival and the departure controllers was, on occasion, effected for an earlier descent.

Dahlgren: Arrival traffic from the south via V157 was started by the ARTCC at Point "F" (Fig. 8). Minimum acceptance altitude was 5000 feet. Handoffs to the transition controller were accomplished as soon as practicable prior to the Dahlgren clearance limit. The Dahlgren transition controller sequenced this traffic, gave descent instructions, and made handoffs to the final controller approximately 5-miles northeast of Dahlgren.

Kent Island: Arrival traffic from the northeast via V16 was started by the ARTCC at Point "D" (Fig. 8). Minimum acceptance altitude was 5000 feet. Handoffs to the transition controller were accomplished as soon as practicable prior to the Kent Island clearance limit. The Kent Island transition controller provided separation between the arrivals landing at Andrews and the arrivals proceeding to Washington, and vectored these latter aircraft towards Nottingham at 5000 feet. At Nottingham these aircraft were turned to a westerly heading and handed off to the Washington final controller. The aircraft were issued descent clearance when west of the Andrews localizer and sequenced with the arrivals from over Riverdale.

Departures

Departures to the south and southwest made a left turn with radar vectors to V3 and maintained 4000 feet until south of Woodbridge intersection (Fig. 9). This restriction was deleted, on occasions, through coordination with the Herndon transition controller.

Prior to the rerouting of Gaithersburg arrivals to the east of Washington Airport, departures to the northwest via V8N were restricted to maintain 4000 feet until northwest of V3. When this rerouting was accomplished, the same departures had no climb restriction other than to cross V223 at or above 6000 feet. Departures via V123 maintained 4000 feet until north of Riverdale to remain under arrival traffic. An unrestricted climb was made after this point.

Washington Airport - Phase I - South Operation

Arrivals

Gaithersburg: Arrival traffic from the north via V3 was handled by the ARTCC in the same manner as in the north operation (Fig. 10). However, after several runs, it became evident that there was insufficient airspace between Point "C" and Gaithersburg for the transition controller to sequence his traffic effectively and complete handoffs to the final controller. Early handoffs to the final controller were mandatory due to the proximity of the Gaithersburg fix to the final approach course, therefore, it was decided to have the center start the traffic at Westminster. This additional mileage resolved the situation. Minimum acceptance altitude was 5000 feet, and aircraft were given further descent instructions after passing Gaithersburg. Handoffs from the transition controller to the final controller vectored the aircraft to the final approach course, with any attendant path-stretching accomplished to the west of V3.

Herndon: ARTCC arrival procedures at Herndon were the same as in the north operation (Fig. 10). Minimum acceptance altitude remained 5000 feet due to Dulles departures. The aircraft were instructed by the transition controller to depart Herndon on a heading of 120° and descent to 4000 feet after passing Herndon. Handoffs from transition to final controller were effected at Herndon, and further descent instructions were given by the final controller when deemed advisable.

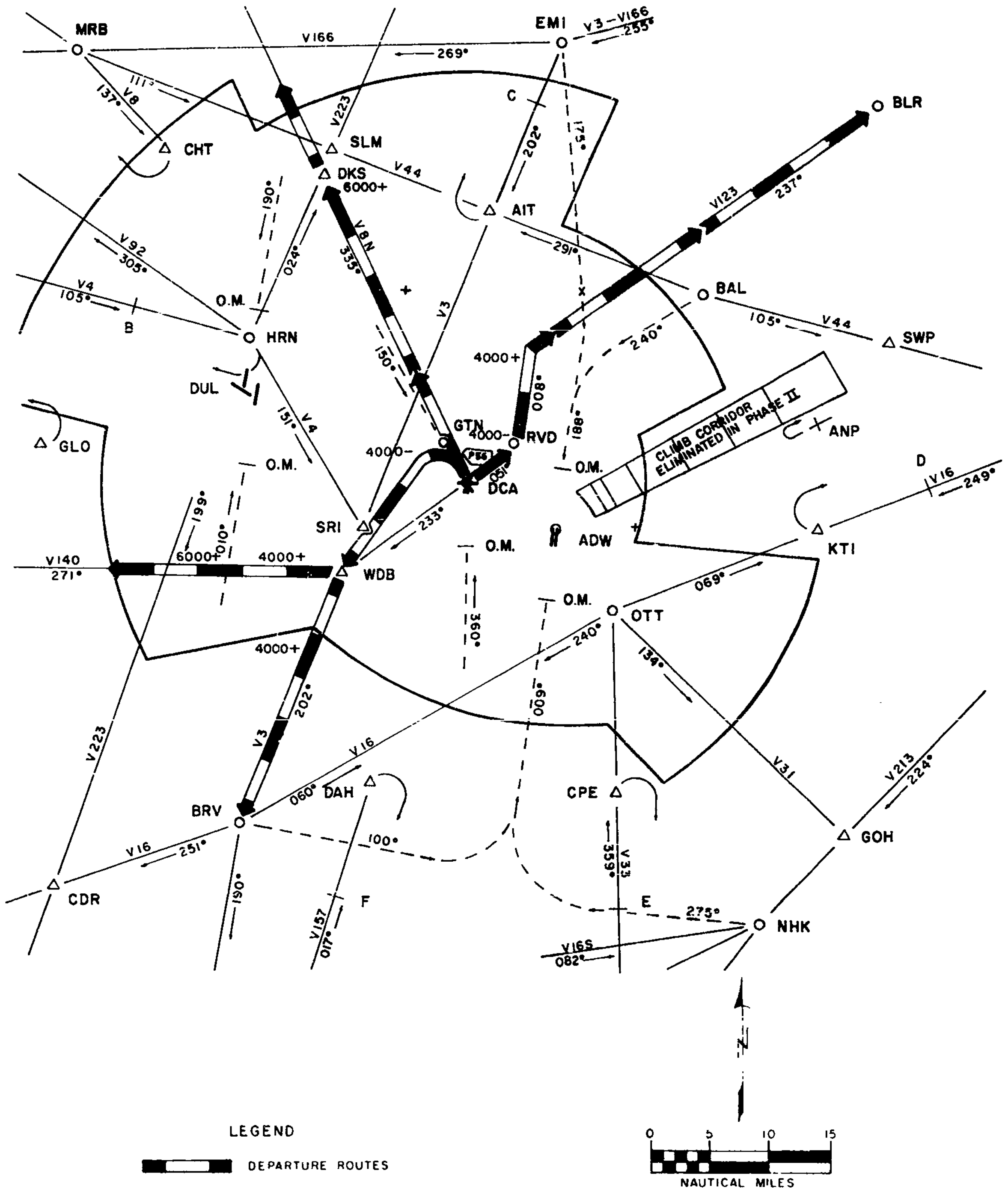


FIG. 9 WASHINGTON DEPARTURE ROUTES - NORTH OPERATION (PHASES I AND II)

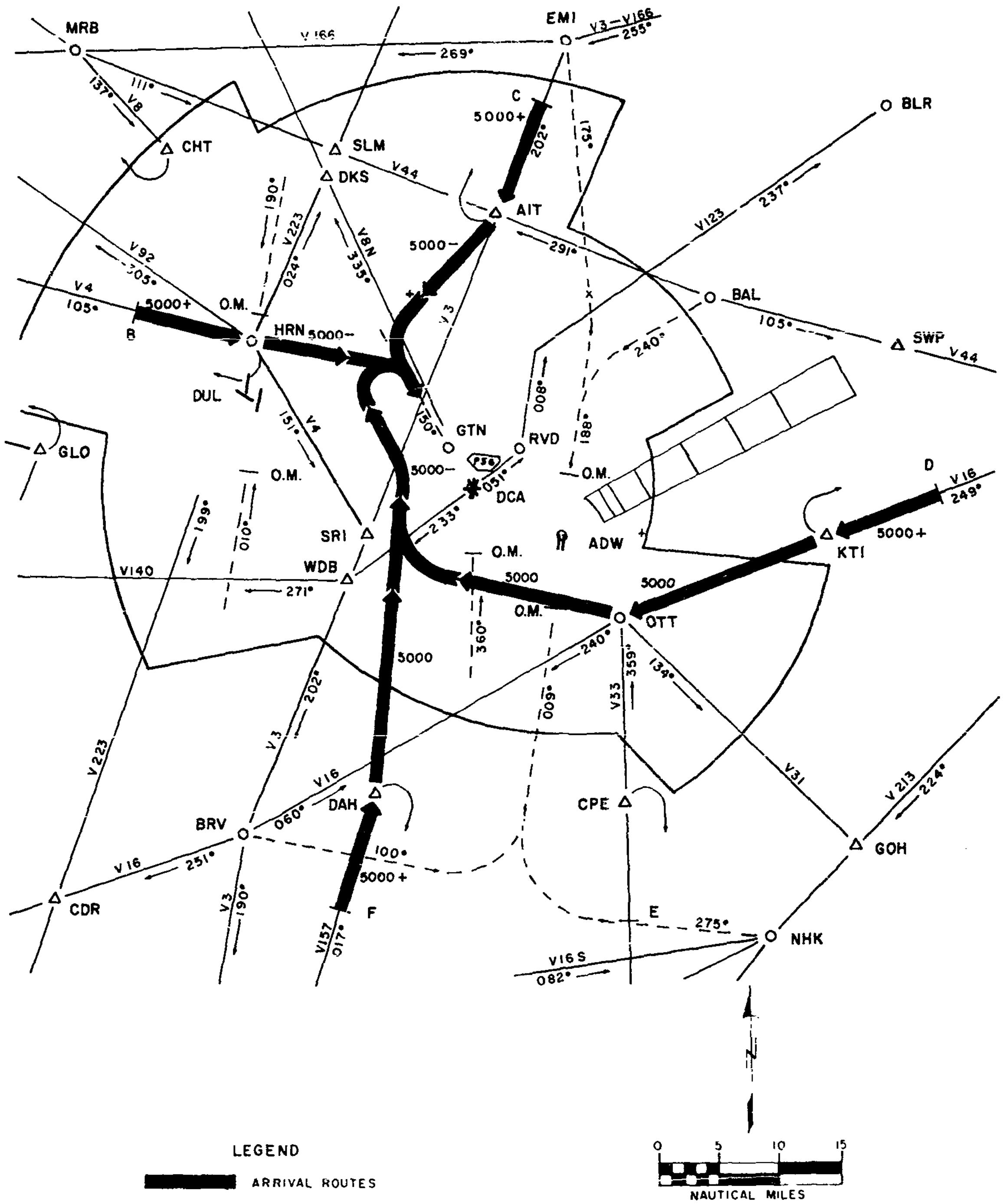


FIG. 10 WASHINGTON ARRIVAL ROUTES - SOUTH OPERATION (PHASE I)

Dahlgren: ARTCC arrival procedures at Dahlgren were the same as in the north operation (Fig. 10). The transition controller vectored these aircraft northbound between V3 and the Washington Airport at 5000 feet. This restriction was due to Washington departures on V140 climbing to 4000 feet. When north of V140, the aircraft were descended to 2500 feet. At this point, a heading to parallel the inbound course was issued, and a handoff accomplished to the final controller.

Kent Island: Arrival traffic from the northeast via V16 was handled by the ARTCC and the Kent Island transition controller in the same manner as the north operation, with the exception that the subject aircraft were handed off to the Dahlgren transition controller at Nottingham rather than to the Washington final controller (Fig. 10). The Dahlgren transition controller integrated this traffic with arrivals from over Dahlgren in the vicinity of Springfield.

Departures

Departures to the south and southwest made a right turn after takeoff and were vectored to Woodbridge, climbing to maintain 4000 feet until south or west of Woodbridge (see Fig. 11). Departures to the north via V123 made a left turn to Riverdale, climbing to cross Riverdale at 4000 feet or above.

The original procedural plan specified that, in a south operation, the Washington departures via V8N make a left turn after takeoff, climbing so as to cross the Washington VOR at 4000 feet. Under this procedure, all aircraft departing Washington and Andrews via V8N and V123 were confined to the airspace between the two airports, creating congestion. To alleviate this situation, departures from Washington via V8N climbed on runway heading to 2000 feet, then made a right turn to the VOR. Aircraft maintained 6000 feet until established on V8N. Traffic in this operation, although vertically separated with arrivals at Georgetown, was in an opposing direction, thereby creating target clutter in this area. It was necessary for the departure controller to vector his traffic along the right side of V8N to maintain identity.

Washington Airport - Phase II - North Operation

Arrivals

Washington traffic in this phase was handled in a manner similar to Phase I, the only exception being that traffic originally routed over Kent Island was now routed over Annapolis (see Fig. 9).

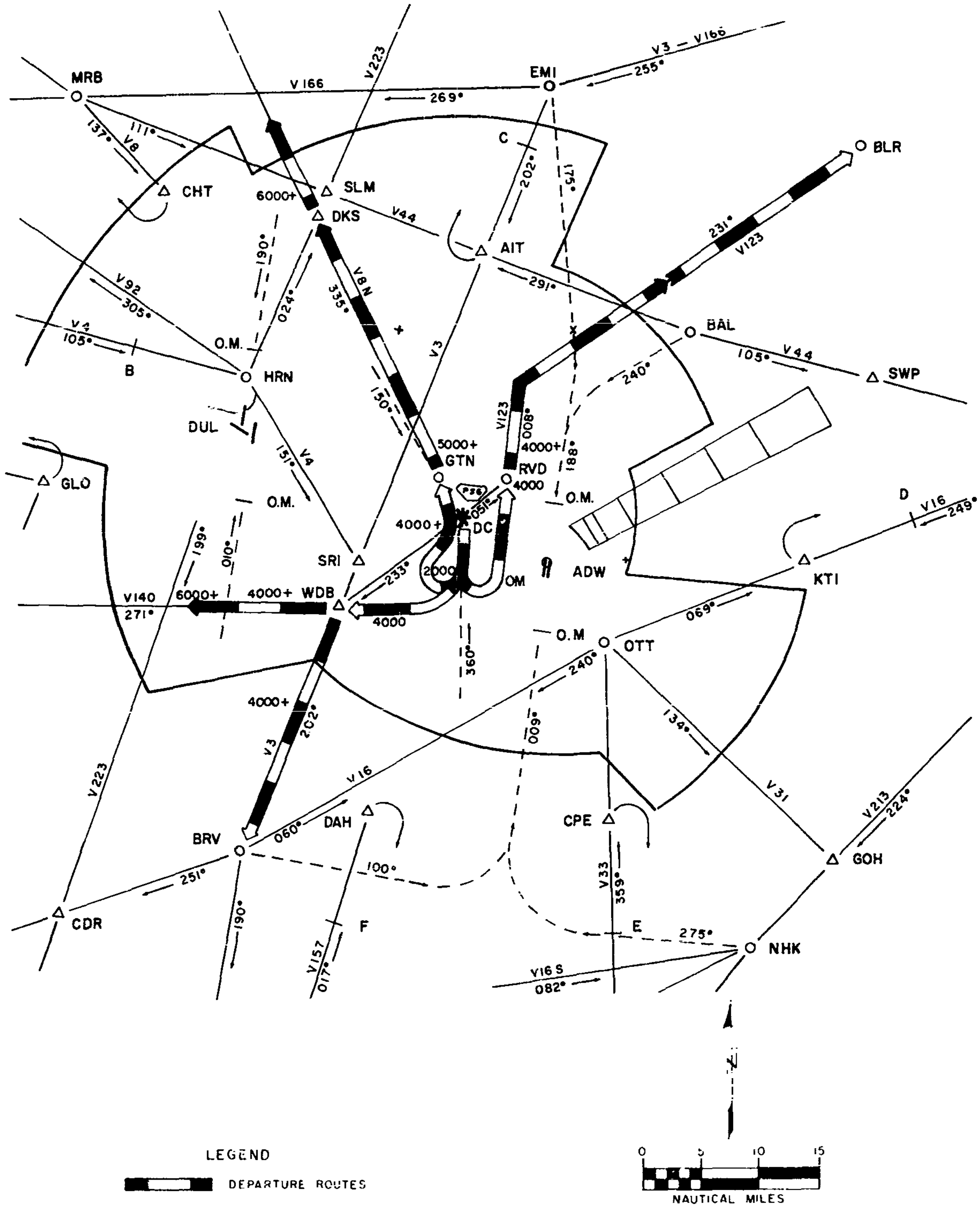


FIG. 11 WASHINGTON DEPARTURE ROUTES - SOUTH OPERATION (PHASE I)

Departures

No change from Phase I (see Fig. 9).

Washington Airport - Phase II - South Operation

Arrivals

In this operation, the Washington arrivals, via Annapolis, were vectored by the Andrews conventional transition controller to the Andrews north outer marker, then to Riverdale. Aircraft were vectored over the Andrews outer marker to insure separation from jets completing Baltimore VOR penetrations to Andrews which were descending to cross the Andrews outer marker at 1500 feet (Fig. 12). Handoffs to the Washington final controller were effected between the Andrews outer marker and Riverdale at 5000 feet. The final controller descended aircraft when clear of V123 on a heading which paralleled the inbound course to Georgetown, and sequenced this traffic with the Gaithersburg arrivals.

Departures

In this operation, departures to the north proceeded via V123S. Aircraft made a left turn in the vicinity of the Washington outer marker and climbed so as to cross the Andrews AFB VOR at or above 3500 feet, but not to exceed 6000 feet, proceeding eastbound on a 109° radial until they intercepted V123S (Fig. 13).

Andrews Airport - Phase I - North Operation

Arrivals

Chesapeake: Conventional traffic arriving from the south via V33 over Chesapeake started at Point "E" (Fig. 14), and were handed off to the transition controller as soon as practicable after leaving this point. Minimum acceptance altitude was 4000 feet. The transition controller descended the aircraft to 1500 feet and issued instructions to depart Chesapeake on a heading of 360° before handing off to the conventional final controller at Chesapeake.

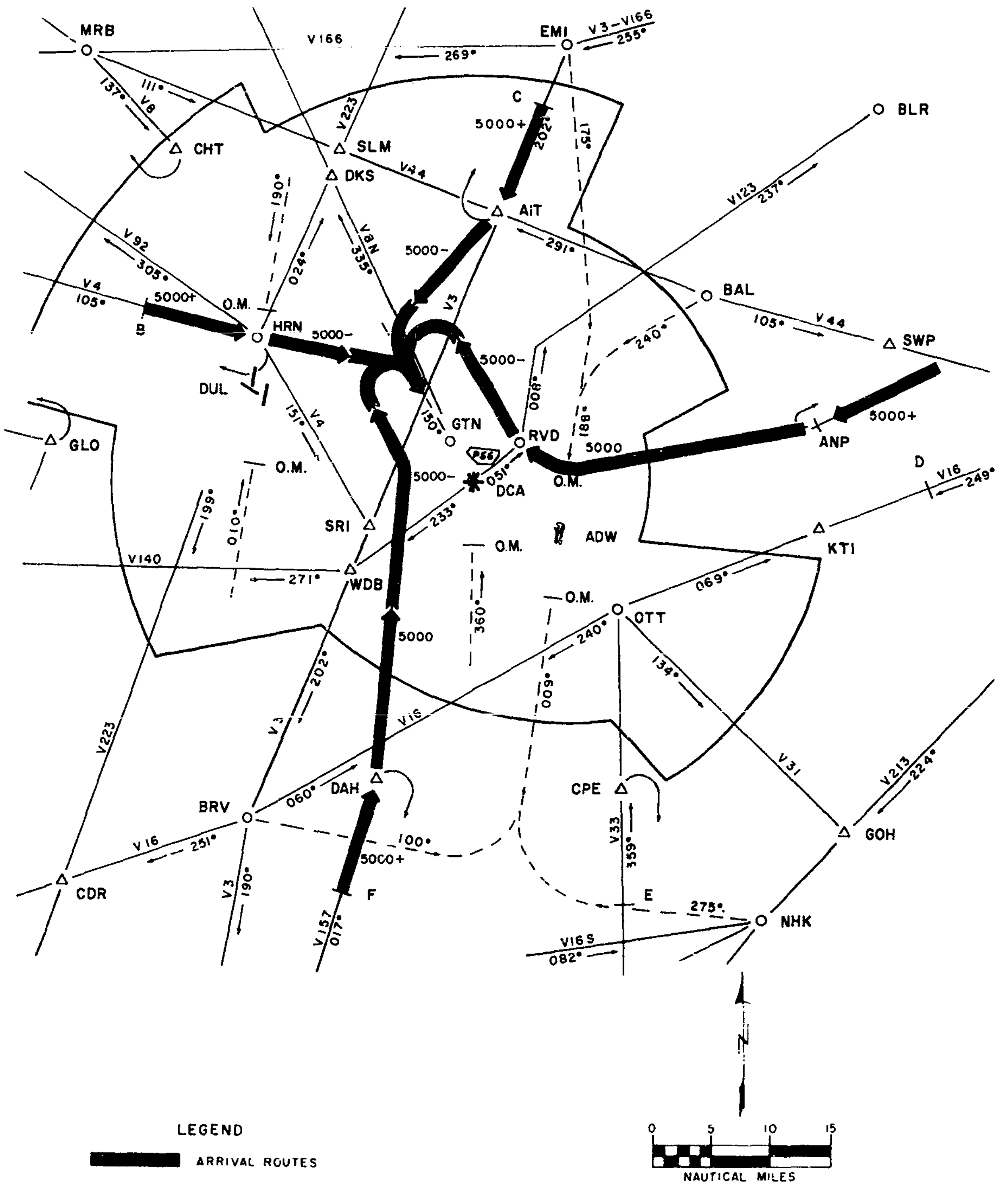


FIG. 12 WASHINGTON ARRIVAL ROUTES - SOUTH OPERATION (PHASE II)

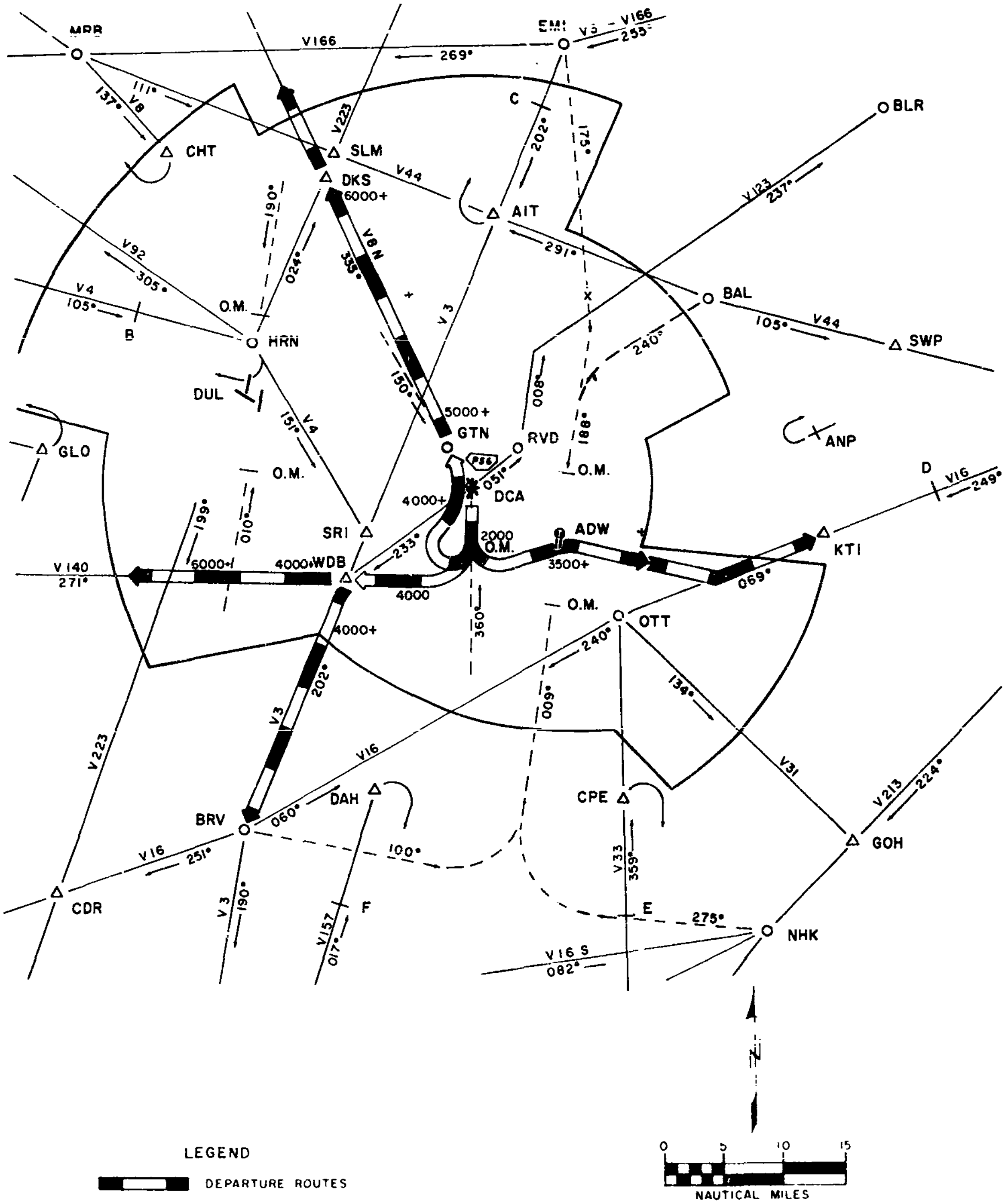


FIG. 13 WASHINGTON DEPARTURE ROUTES - SOUTH OPERATION (PHASE II)

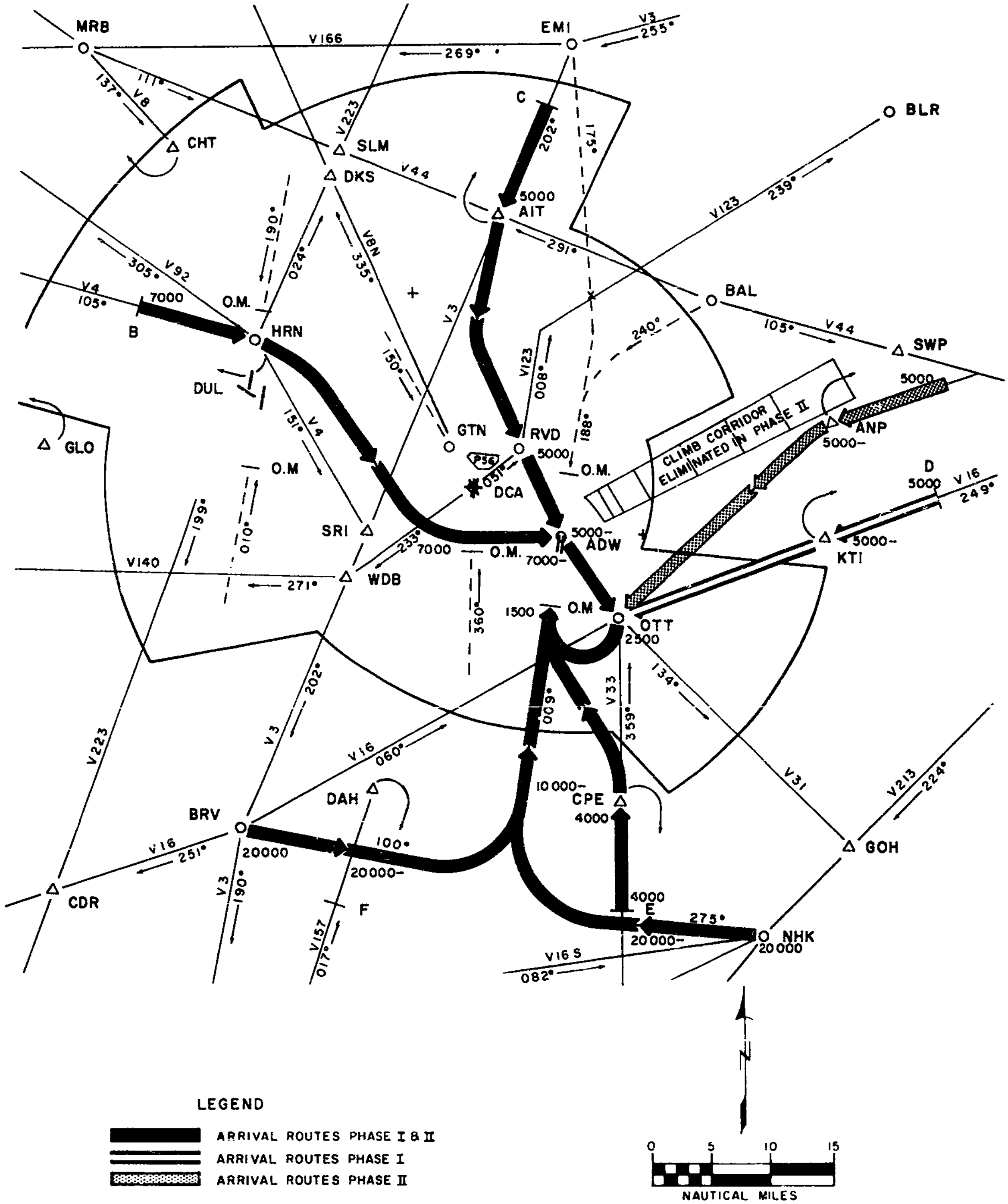


FIG. 14 ANDREWS ARRIVAL ROUTES - NORTH OPERATION (PHASES I AND II)

Herndon: Arrival traffic from the west via V4 to Herndon were handed off to the Washington transition controller by the ARTCC at 7000 feet. Aircraft started at Point "B" (Fig. 14), and handoffs were accomplished between Point "B" and Herndon. The Washington transition controller vectored the aircraft to a point approximately 6 miles south of the Washington Airport. Altitude was maintained until the aircraft had cleared the Herndon holding pattern airspace. Descent to 5000 feet was at the discretion of the Washington transition controller, who insured aircraft being at this altitude prior to handoff. Handoffs were made passing the Washington localizer course to the Andrews conventional final controller, who then descended the aircraft to 1500 feet and vectored to the ILS final approach course. Due to the limited vector airspace available to the final controller between the point of handoff and the final approach course, his ability to sequence this traffic effectively with other arrivals on the final approach course was impeded. The inadequacy in the above procedure was resolved by requiring the Washington transition controller to vector the aircraft at 7000 feet from over Herndon to the vicinity of the Washington outer marker. At this point, the Washington transition controller turned the aircraft to an easterly heading, and a handoff was accomplished to the Andrews conventional transition controller. The Andrews transition controller descended the aircraft to maintain 5000 feet until east of Andrews and clear of departure traffic which were climbing to 4000 feet on the departure route to Nottingham. These arrivals were then descended to 2500 feet and handed off to the Andrews conventional final controller. This procedure made it necessary for the final controller to give the aircraft an extended vector pattern to afford sufficient time to descend to approach altitude. Due to the low density of departures using the Nottingham V31 route, a restriction of 1500 feet, until clear of the arrival routes, was applied to these aircraft. This restriction allowed the Andrews transition controller to descend arrival traffic to 2500 feet when passing Andrews, and effect a handoff to the final controller approximately 2 miles east of the airport. The procedural plan was modified to reflect this change.

Gaithersburg: Arrivals from the north via V3 to Gaithersburg started at Point "C" (Fig. 14), and were handed off by the ARTCC to the Washington National transition controller approximately 5 miles north of Gaithersburg at 5000 feet. The transition controller vectored the aircraft from over Gaithersburg to Riverdale, departing Gaithersburg on a heading of 190°, maintaining this heading to the north edge of V8N, the direct to Riverdale. In the vicinity of Riverdale, handoffs were made to the Andrews conventional transition controller, who vectored the aircraft at 5000 feet from the point of handoff southeastbound over Andrews. The remainder of the procedures used to control this traffic were commensurate with the procedures used in the control of the Herndon arrival traffic, including the revision due to the restriction of V31 departure traffic.

Kent Island: Conventional traffic arriving via V16 to Kent Island started at Point "D" (Fig. 14), and was handed off to the Andrews conventional aircraft transition controller approximately 7 miles east of Kent Island at 5000 feet. The transition controller vectored the aircraft from the point of handoff to approximately 5 miles north of Chesapeake, maintaining 5000 feet until clear of departure traffic climbing to 4000 feet on V31. When the aircraft cleared the V31 departure route, they were descended to 2500 feet and handed off to the Andrews conventional aircraft final controller. When the restriction of 1500 feet was applied to Andrews departures proceeding via V31, the transition controller cleared the Kent Island arrivals from over Kent Island V16 to Nottingham, to cross Nottingham descending to 2500 feet. Handoffs to the final controller were effected in the vicinity of Nottingham. This revised procedure afforded the aircraft a shorter vector pattern and the opportunity to make a normal rate of descent to approach altitude.

Jet: The majority of traffic programmed to arrive at Andrews were of the jet type requiring penetrations. These aircraft started from over the fix from which they made their approach. All aircraft entered at the initial penetration altitude of 20,000 feet and, depending on the direction of landing, contacted the Andrews jet transition controller over Brooke or Patuxent River on a north operation, or Baltimore on a south operation. Aircraft were radar-identified over the approach fix by the transition controller, and were subsequently cleared to penetrate to 2500 feet. The aircraft were provided radar separation from preceding and succeeding flights by the transition controller, and radar handoffs to the Andrews jet final controller were accomplished while the aircraft were in penetration turn. The final controller spaced the jet traffic with the traffic being handled by the Andrews conventional aircraft final controller. These procedures were utilized for both Phase I and Phase II.

Departure

Jet

All jet aircraft departing Andrews made a right turn after takeoff and climbed to an assigned altitude in the climb corridor before proceeding on course. The departure controller ensured radar separation with any aircraft at a conflicting altitude.

Conventional:

1. Conventional aircraft departing to the northeast via V123 made an unrestricted climb to cruise altitude (Fig. 15). The aircraft maintained runway heading until intercepting V123, then proceeded on course. Aircraft were provided radar separation from preceding and succeeding flights departing Washington and Andrews until longitudinal or vertical separation was established.

2. Aircraft departing to the south or southeast via Nottingham V31 made a right turn after takeoff and proceeded direct to Nottingham, climbing to 4000 feet. These aircraft maintained not above 4000 feet until clear of V33. This procedure was subsequently amended to 1500 feet for reasons enumerated previously under "Kent Island," and was normally deleted after coordination.

3. Aircraft departing to the northwest via V8N proceeded via runway heading to the outer marker then direct to Riverdale with vectors to V8N. The Andrews departure controller coordinated with the Washington departure controller working traffic on V123 for an altitude at Riverdale. The aircraft maintained not above 4000 feet until clear of the arrival route from over Gaithersburg, and then climbed to cruise altitude.

4. Aircraft departing to the south and southwest, via Woodbridge V3 or V140 made a left turn immediately after takeoff and were vectored to intercept V3 at Woodbridge. Aircraft maintained not above 4000 feet until past Woodbridge, at which time they were cleared to cruise altitude. This procedure created a hazardous condition where the departures crossed the Washington arrival route from over Gaithersburg. It also became apparent that low-performance aircraft departing Andrews were conflicting with aircraft on the ILS final approach course at Washington. This problem was resolved by requiring these departures to proceed via runway heading to the

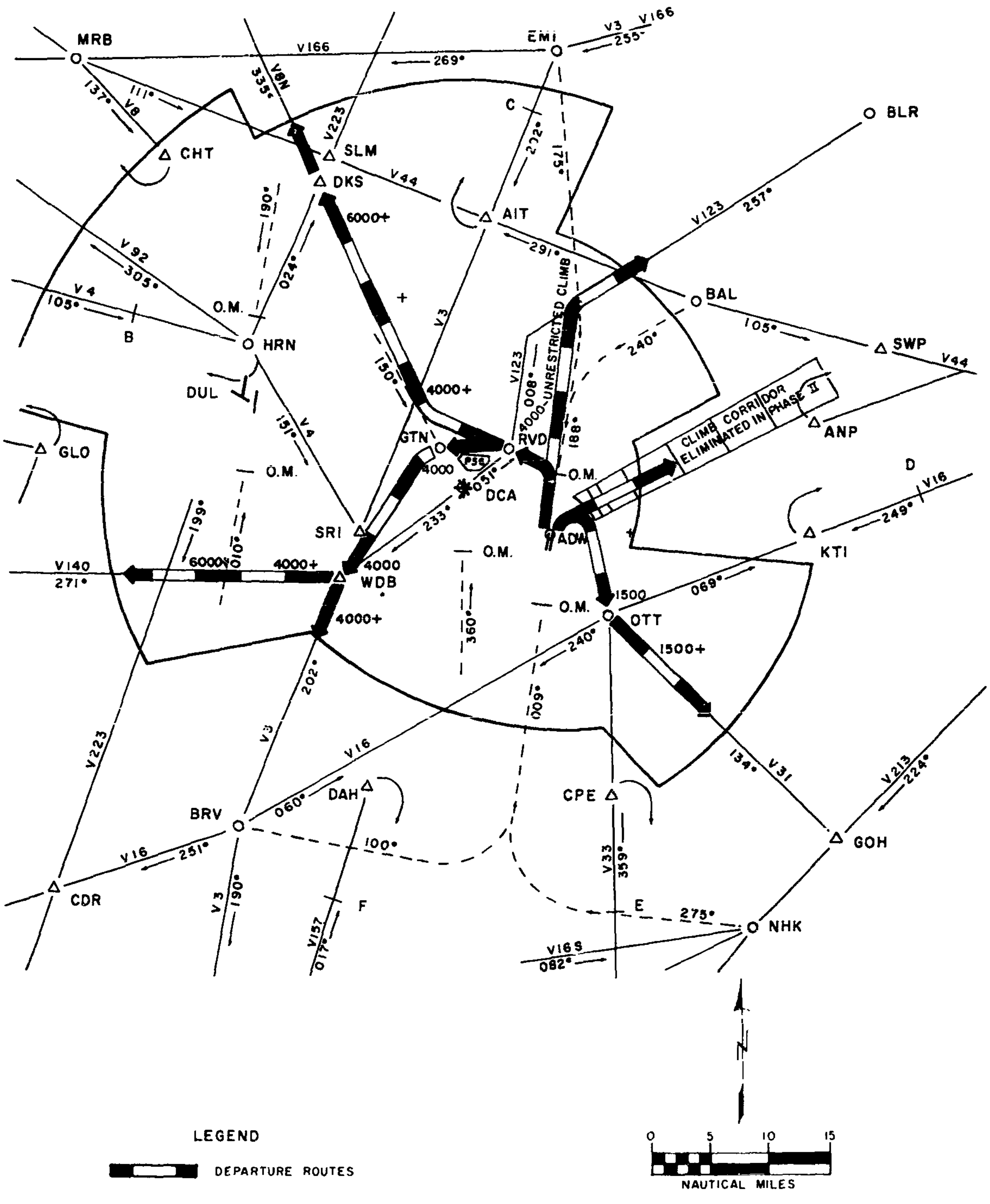


FIG. 15 ANDREWS DEPARTURE ROUTES - NORTH OPERATION (PHASES I AND II)

outer marker and vectored over Riverdale and Georgetown to Woodbridge, maintaining not above 4000 feet until past Woodbridge. This procedure increased the flight path of the departure slightly, but was justified by the alleviation of a difficult situation. Traffic proceeding via V140 crossed V223 at 6000 feet or above to clear the Dulles departure route. The procedural plan was amended to reflect this change.

Andrews Airport - Phase I - South Operation

Arrivals

Chesapeake: Arrival aircraft from the south via V33 to Chesapeake were handed off to the Andrews conventional aircraft transition controller at 5000 feet in the same manner as in the north operation (Fig. 16). The transition controller instructed the aircraft to depart Chesapeake on a heading of 010° to maintain 5000 feet. The aircraft were held at 5000 feet until clear of the Andrews departure route for aircraft proceeding via Nottingham V31. This required the aircraft to maintain 5000 feet until approximately 5 miles north of Nottingham, at which time the transition controller descended them to 2500 feet and handed off to the Andrews conventional final controller. When the transition controller working the Chesapeake clearance limit was given control of 2500 feet and above, it enabled him to start descending aircraft to 2500 feet immediately after accepting control from the Center. He then cleared the aircraft to depart Chesapeake on a heading of 010° and handed off to the Andrews final controller approximately 8 miles north of Chesapeake. The final controller vectored the aircraft along the east side of the airport, spacing them with other traffic. The final controller descended the aircraft to 1500 feet when clear of the V31 departure route, and turned them onto the ILS final approach course approximately 2 miles north of the outer marker. Andrews departures proceeding via Nottingham V31 were restricted to 1500 feet until clear of V33, or about 6 miles southeast of Nottingham. Normally, this restriction was deleted by the Andrews departure controller after coordination with the transition controller working the Chesapeake clearance limit. This revision reduced coordination between arrival and departure controllers and made for a smoother flow of inbound traffic to the airport. The altitude restriction appeared to be of little consequence to the type aircraft normally using this route.

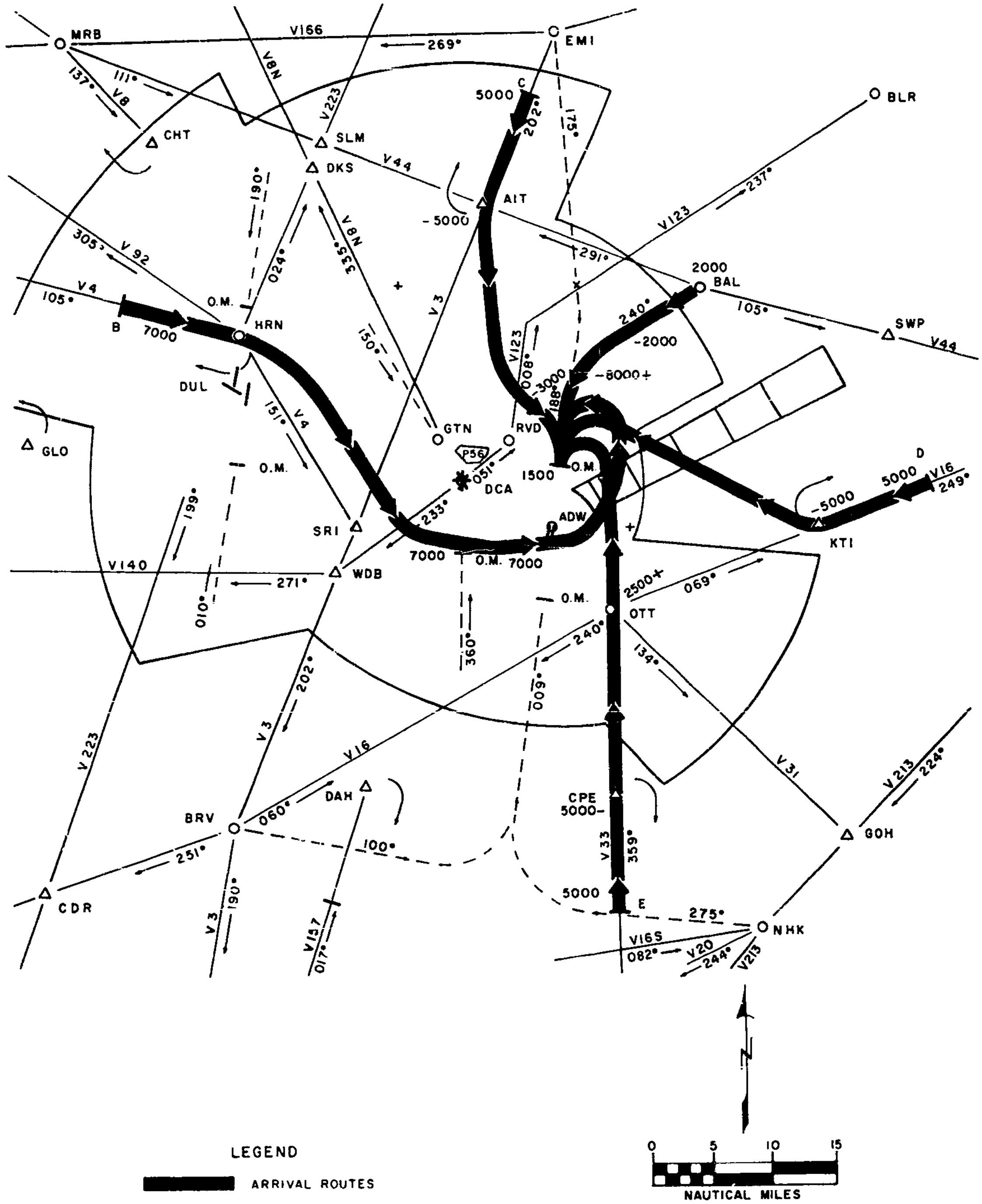


FIG. 16 ANDREWS ARRIVAL ROUTES - SOUTH OPERATION (PHASE I)

Herndon: The procedures for the control of this traffic were the same as the amended procedures used for handling the Herndon traffic in the Phase I north operation (Fig. 16).

Gaithersburg: Handoffs from the ARTCC were accomplished in the same manner as described in the north operation (Fig. 16). The Washington transition controller vectored the aircraft from over Gaithersburg toward Riverdale, descending them to cross V123 at 3000 feet. At a point approximately 5 miles north-northwest of Riverdale, the aircraft were turned to a heading of approximately 090° and handed off to the Andrews conventional aircraft final controller, who completed the vector to the ILS final approach course.

Kent Island: Handoffs from the ARTCC were accomplished in the same manner as described in the north operation (Fig. 18). The Andrews conventional controller instructed the aircraft to depart Kent Island on a 300° heading, concurrently descending to 1500 feet. Handoffs to the Andrews conventional aircraft final controller were accomplished approximately 5 miles west of Kent Island.

Departures

Jet

Jet aircraft climbed unrestricted on the runway heading to an assigned altitude before proceeding on course. The Andrews jet departure controller provided radar separation with all conflicting traffic (Fig. 17).

Conventional

1. Aircraft proceeding northeast via V123 made a right turn after takeoff heading 360° to intercept the airway, then climbed to cross the 051° radial of Washington National VOR at 4000 feet, and continued climb to cruise altitude (Fig. 17).

2. Aircraft departing to the northwest via V8N climbed on the runway heading to 2000 feet, then made a right turn and were vectored to the Washington VOR. The aircraft maintained not above 4000 feet until north of the Washington outer marker and not above 6000 feet until past Georgetown. This procedure created a hazardous condition in the vicinity of the Washington outer marker with high-performance aircraft climbing out of Washington making a left turn to Riverdale. The problem was resolved by

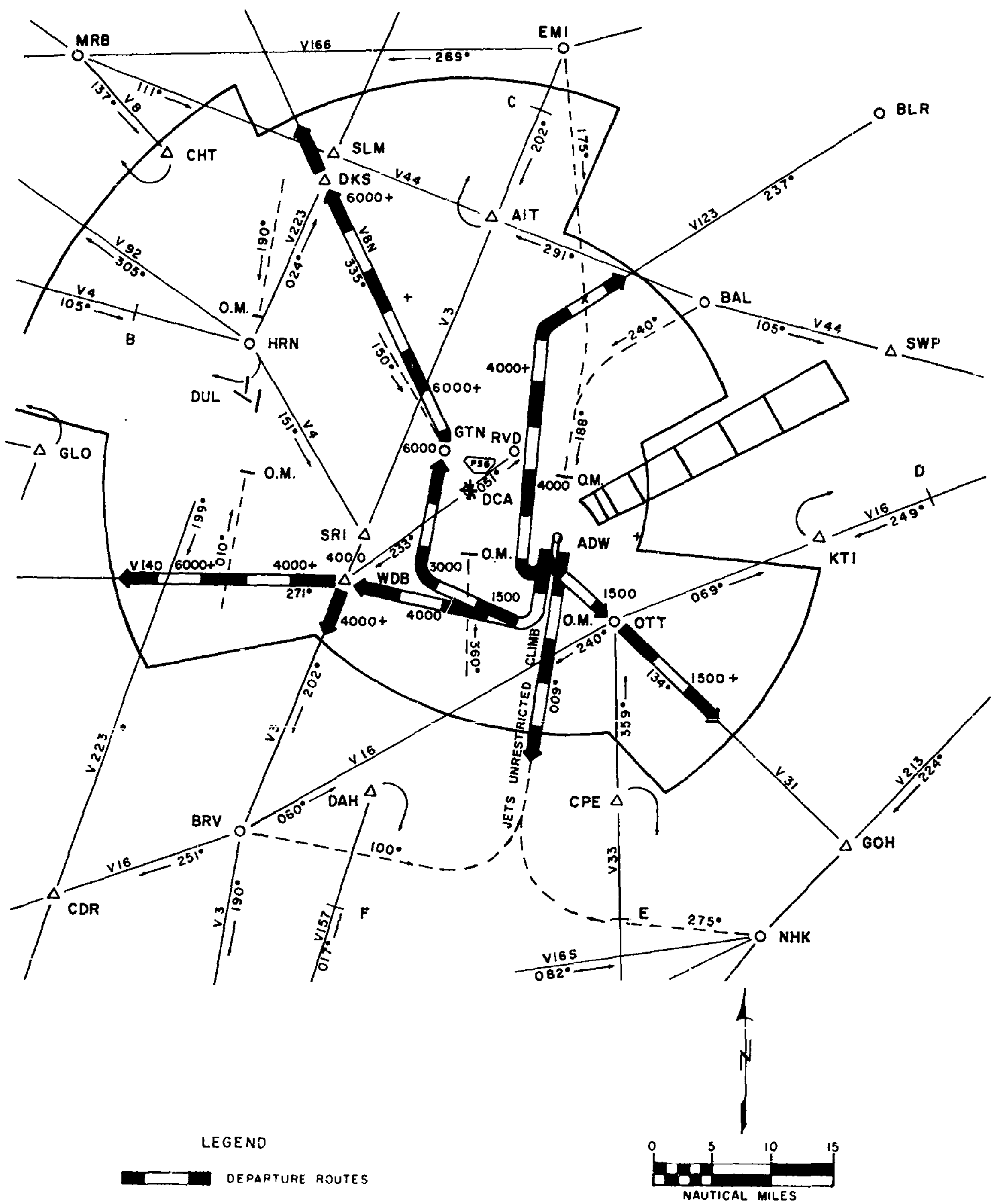


FIG. 17 ANDREWS DEPARTURE ROUTES - SOUTH OPERATION (PHASE I)

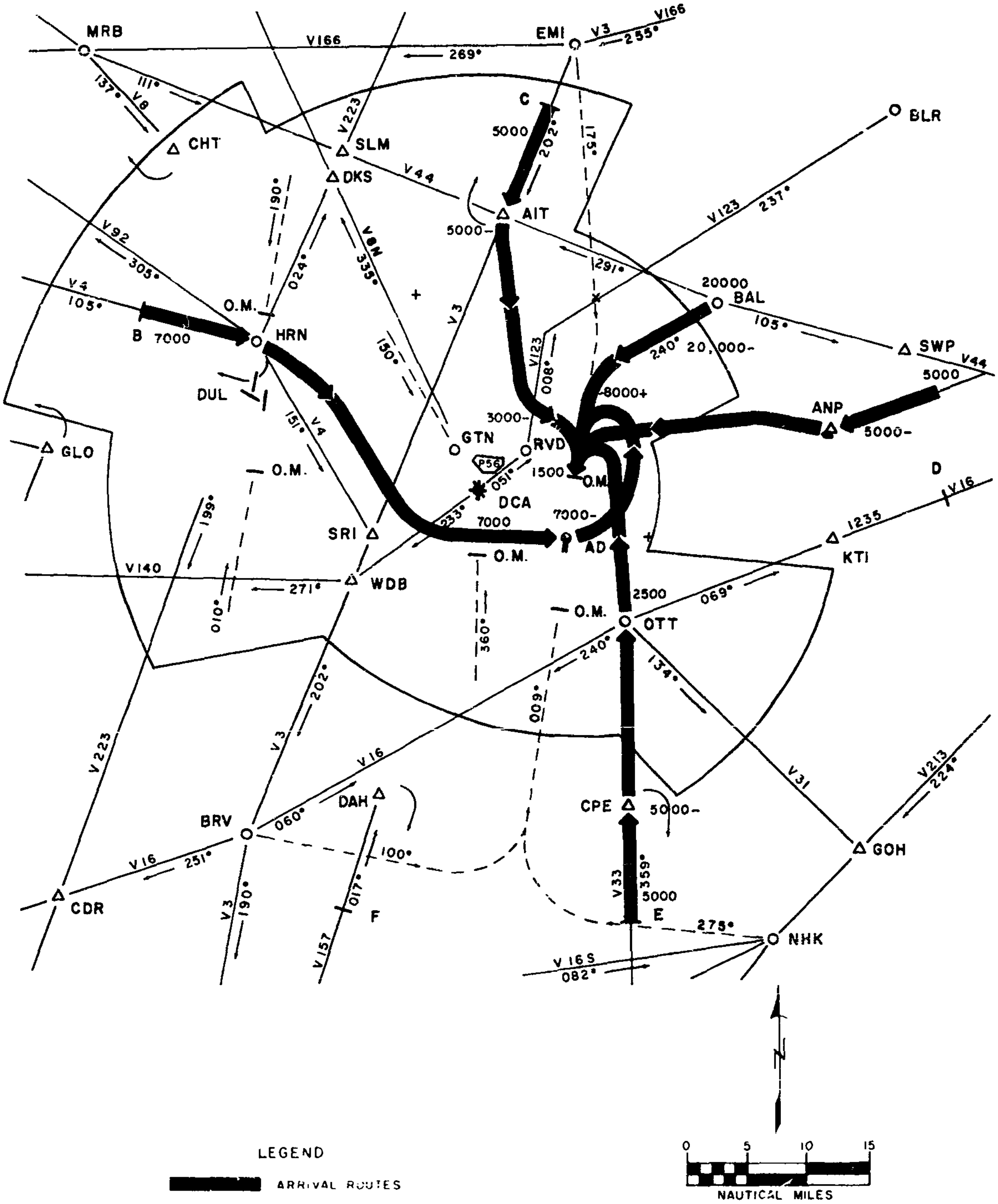


FIG. 18 ANDREWS ARRIVAL ROUTES - SOUTH OPERATION (PHASE II)

requiring the Andrews departures to climb on the runway heading to 1500 feet, and then make a right turn to a heading at 290°. On this heading, the aircraft climbed to 3000 feet and were vectored to intercept V8N in the vicinity of Georgetown, maintaining not above 6000 feet until established on the airway. This procedure kept the Andrews departures south and west of the Washington departure route over Riverdale. The climb to cruise altitude was continued after passing Georgetown. The procedural plan was revised to include this procedure.

3. Aircraft departing to the south via V31 over Nottingham made a left turn after takeoff and proceeded direct to Nottingham, climbing to 4000 feet. The aircraft maintained 4000 feet until clear of V33, then climbed to cruise altitude. It was found that a restriction of 1500 feet until south of Nottingham, clear of V33, should be applied to these departures to afford the arrival controller working the Chesapeake clearance limit the opportunity to descend the arrival traffic sooner. This restriction posed no appreciable problem to departure aircraft, due to the short distance from Andrews to Nottingham and the limited number of aircraft using this route.

4. Aircraft departing to the west or southwest via Woodbridge V3 or V140 made a right turn after takeoff and were vectored to Woodbridge on course, maintaining not above 4000 feet until past Woodbridge. Traffic proceeding via V140 crossed V223 at 6000 feet or above in order to clear the Dulles departure route.

Andrews Airport - Phase II - North Operation

Arrivals

Chesapeake: Procedures applied to the handling of this traffic were the same as in Phase I (Fig. 14).

Herndon: Procedures applied to the handling of this traffic were the same as in Phase I.

Annapolis: The same procedures used to handle the Kent Island traffic on a north operation were applied to the Annapolis traffic, which proceeded direct to Nottingham, as opposed to Kent Island traffic, which proceeded via V16 to Nottingham.

Gaithersburg: Procedures applied to the handling of this traffic were the same as in Phase I.

Departures

Jet

Jet departures made a right turn after takeoff to a heading of 050°, climbing to assigned altitude before proceeding on course. The departure controller provided radar separation from all conflicting traffic (Fig. 15).

Conventional

All conventional departure procedures remained the same as in Phase I.

Andrews Airport - Phase II - South Operation

Arrivals

Chesapeake: Arrival aircraft via V33 to Chesapeake were handled in the same manner as in Phase I South, with the exception that the inbounds were descended to cross Nottingham at 2500 feet (Fig. 18). This was necessary due to the Washington departures proceeding via V123S, passing 5 miles north of Nottingham at 3500 feet or above.

Herndon: The only procedural change from Phase I South was the utilization of 3500 to 6000 feet for Washington departures proceeding over the Andrews VOR to V123S. This necessitated the Andrews transition controller keeping arrivals over Herndon at 7000 feet until northeast of Andrews Airport. When the aircraft reached a point northeast of Andrews, clear of the departure route, the Andrews transition controller descended them to 2500 feet and effected handoffs to the Andrews final controller. The disadvantage of this procedure was the increased vector pattern required to afford sufficient time for the aircraft to descend to approach altitude. Occasionally, aircraft were descended sooner when the Andrews transition controller coordinated with the Washington departure controller. The remainder of the procedures were unchanged.

Gaithersburg: The same procedures were used to handle this traffic as in Phase I.

Annapolis: With one exception, the same procedures were used in this operation as in Phase I South, Kent Island. The traffic arrived via the Annapolis clearance limit instead of Kent Island, and departed Annapolis on a vector of 280°.

Departures

Jet

The jets used the same departures as in Phase I South (Fig. 19).

Conventional

1. Aircraft departing Andrews to the northeast via V123S made a left turn and proceeded direct to Nottingham on course. They maintained not above 1500 feet until northeast of Nottingham, clear of the Chesapeake arrival route.

2. V8N - The same procedures applied to traffic proceeding via this route as in Phase I South.

3. V31 - The same procedures applied to traffic proceeding via this route as in Phase I South.

4. V140, V3 - The same procedures applied to traffic proceeding via this route as in Phase I South.

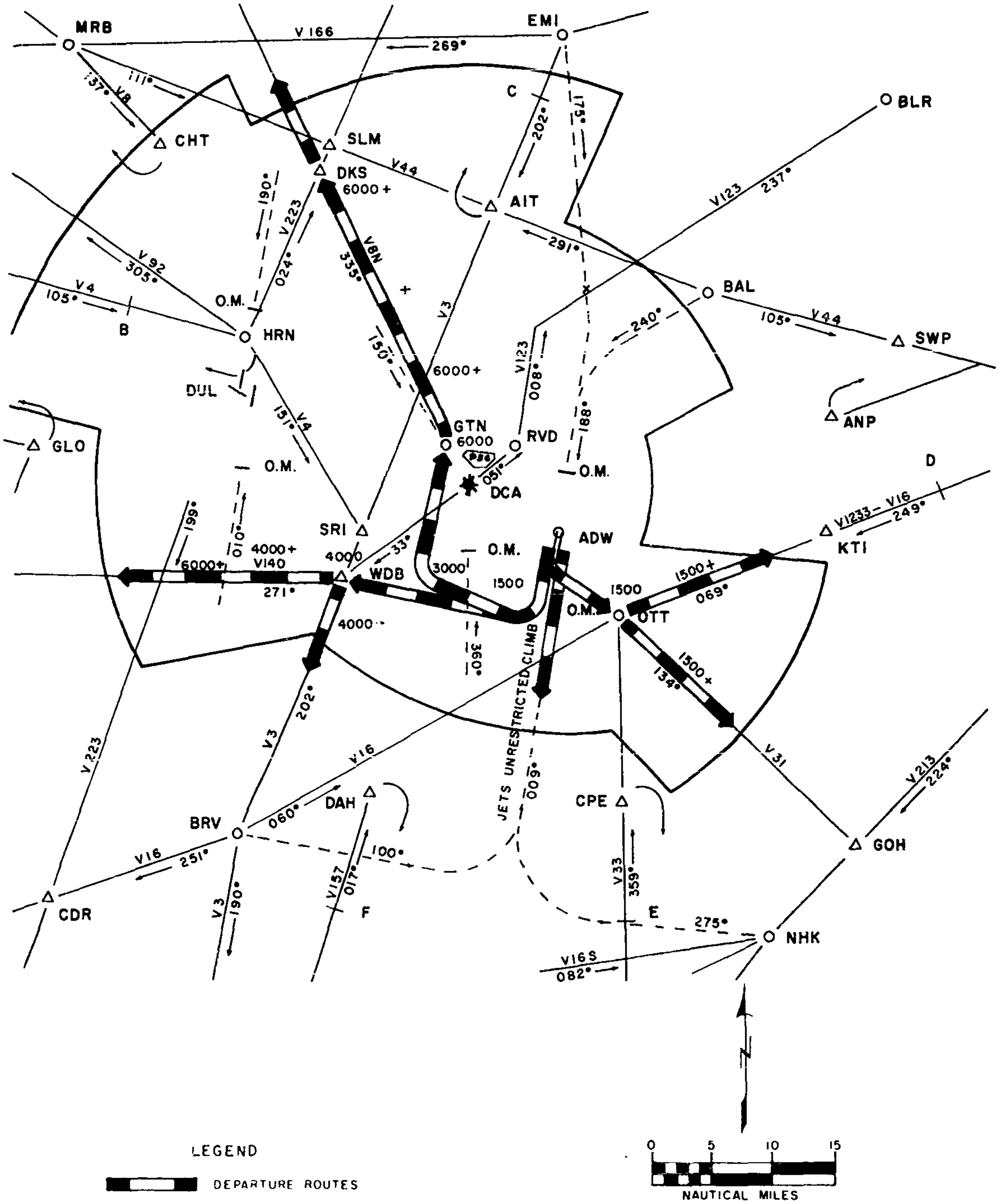


FIG. 19 ANDREWS DEPARTURE ROUTES - SOUTH OPERATION (PHASE II)

EQUIPMENT CONFIGURATIONS

Figures 20 through 35 depict the procedures and equipment configurations in both Phase I and Phase II, with either wind condition. Figures 20, 25, and 30 are sketches of the three equipment configurations as received from the Washington planning team prior to the dynamic simulation; Figs. 21, 26, and 31 are sketches of the three equipment configurations as modified for data runs. Changes in equipment layouts were made in an effort to facilitate required coordination.

The modified equipment configurations do not necessarily reflect the ideal structure, as there are problem areas in each which leave something to be desired. These areas are described as follows:

Hangar 6

The Hangar 6 equipment configuration has no apparent disadvantages with respect to intrafacility coordination. In the airspace delegated to this facility, there are no major conflicting points and each airway, in general, is controlled by a single controller. Handoffs to the ARTCC facility are effected by "hot lines." The handoff points as proposed are quite close to en route crossing airways. This puts the burden of separation between arrivals, en route, and departure aircraft on the en route facility.

In-Line

Due to the flow of traffic from the en route sectors, the Washington transition arrival controller controlling arrivals from Herndon, Dahlgren, and Kent Island is physically separated from his counterpart transition arrival controller and the final controller with whom he must effect handoffs. Although the controllers effectively handled their positions with no adverse results, this method of operation is not in agreement with presently recognized concepts of traffic control. Where two controllers are sequencing aircraft at (in most cases) the same altitudes and in restricted amounts of airspace, very close coordination is a prerequisite. Coordination by telephone lines does not always fulfill this requirement.

Butterfly

In the Butterfly configuration, the transition arrival controllers for Dulles, Washington, and Andrews, respectively, are separated by a distance of 6 feet. In the case of Andrews and Dulles, they are also prevented from seeing each other directly by the presence of another controller sitting between them. Without destroying the basic Butterfly appearance of the configuration, there was no solution to this problem. It is felt that, where two controllers are sequencing traffic destined for the same airport and in the same general area, these controllers should be operating from the same scope or from scopes that are as close together as possible.

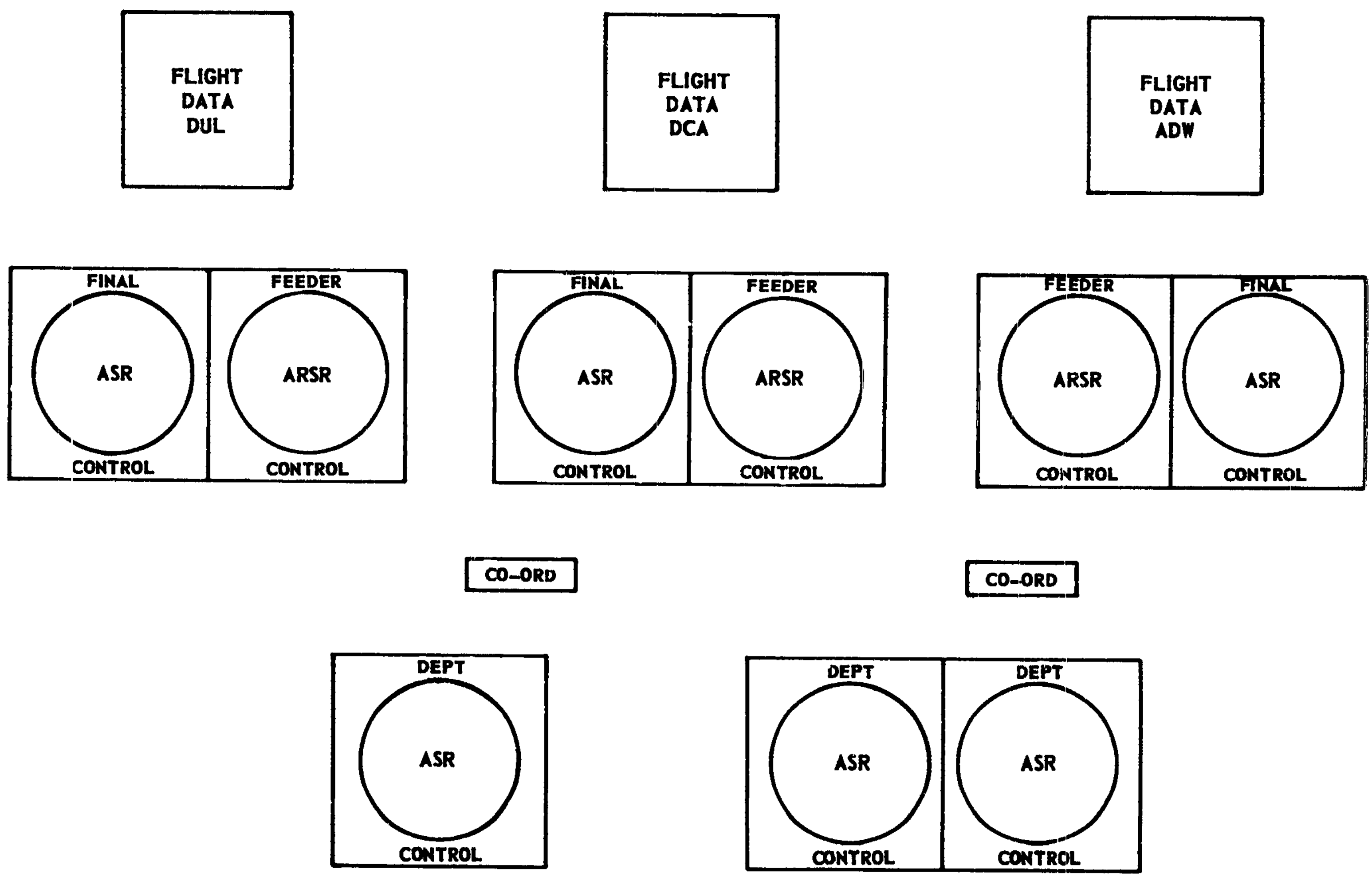


FIG. 20 HANGAR 6 ORIGINAL EQUIPMENT CONFIGURATION (SKETCH)

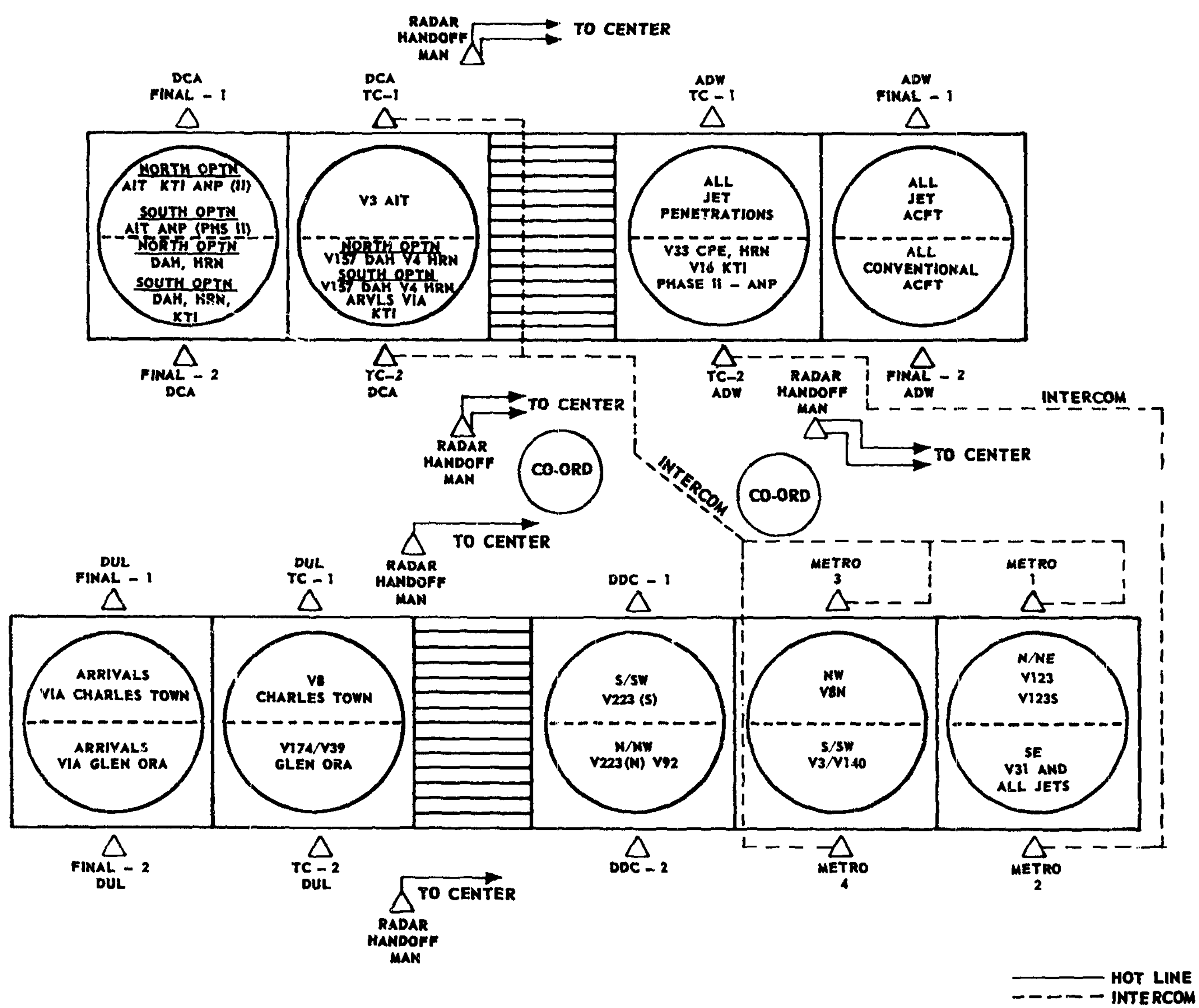


FIG. 21 HANGAR 6 MODIFIED EQUIPMENT CONFIGURATION (SKETCH)

FIG. 22 HANGAR 6 MODIFIED EQUIPMENT CONFIGURATION

	POSITION	DESCRIPTION	DEPARTURE ROUTE	ARRIVAL ROUTE	ARRIVAL FIX	RESTRICTION POINT	RESTRICTION ALTITUDE	COORDINATION NEEDED WITH	COORDINATION METHOD	PRIORITY[1]	HANDOFFS FROM	HANDOFFS TO
DULLES AIRPORT												
1	DDC-1	DEPARTURE	V223(S)			CLEAR OF HRN TSO UNTIL SOUTH V140	40- 50	DCA TC-2 METRO-4	COORDINATOR DIRECT	C B		CENTER
2	DDC-2	DEPARTURE	V223(N) V92			CLEAR OF HRN TSO NORTH OF V8N WEST OF CHT ARRIVAL VECTORING PATH CLEAR OF HRN TSO	40- 50- 20- 40-	DCA TC-2 METRO-3 TC-1 DCA TC-2	COORDINATOR DIRECT DIRECT COORDINATOR	C B B C		CENTER CENTER
3	TC-1	ARRIVALS		V8	CHT	CROSSING V92 ENTERING V4	30+ 40-	DDC-2 DCA TC-2 TC-2 FINAL-1	DIRECT COORDINATOR DIRECT DIRECT	B C A A	CENTER[2]	FINAL-1
4.	TC-2	ARRIVALS		V174/V39	CLO			TC-1 FINAL-2	DIRECT DIRECT	A A	CENTER[2]	FINAL-2
5	FINAL-1	FINAL APCH		VECTORS TO FINAL				FINAL-2 TC-1	DIRECT DIRECT	A A	TC-1	
6.	FINAL-2	FINAL APCH		VECTORS TO FINAL				FINAL-1 TC-2	DIRECT DIRECT	A A	TC-2	
WASHINGTON AIRPORT												
7	TC-1	ARRIVALS		(DCA) V3 (ADW) V3	AIT AIT	SOUTH OF RVD SOUTH OF RVD	50 50	METRO-1 METRO-1 FINAL-1 ADW TC-2	INTERCOM INTERCOM DIRECT DIRECT	C C A A	CENTER[2] CENTER[2]	FINAL-1 ADW TC-2
8	TC-2	ARRIVALS		(DCA) V4 (ADW) V4 (DCA) V157	HRN HRN DAH	SOUTH OF V140 OVER ADW AIRPORT	50 70	METRO-4 ADW TC-2 DCA FINAL-2 ADW TC-2	INTERCOM DIRECT DIRECT DIRECT	B A A A	CENTER[2] CENTER[2] CENTER[2]	DCA FINAL-2 ADW TC-2 DCA FINAL-2
9	FINAL-1	FINAL APCH		VECTORS TO FINAL				FINAL-2 TC-1	DIRECT DIRECT	A A	DCA TC-1 ADW TC-2	
10	FINAL-2	FINAL APCH		VECTORS TO FINAL				FINAL-1 TC-2	DIRECT DIRECT	A A	DCA TC-2	
ANDREWS AIRPORT												
11	TC-1	ARRIVALS		PENETRATIONS	NHK BRV	STANDARD PENETRATION STANDARD PENETRATION		ADW FINAL-1 ADW FINAL-1	DIRECT DIRECT	A A	CENTER[2] CENTER[2]	ADW FINAL-1 ADW FINAL-1
12	TC-2	ARRIVALS		V33 (ADW) V16 (DCA) V16 V3 V4	CPE KTI KTI AIT HRN	 SOUTH OF V31 UNTIL WEST ADW ILS CROSSING RVD CROSSING OTT CROSSING ADW CROSSING OTT	 25 50 50 25+ 70 25+	ADW FINAL-2 METRO-2 ADW FINAL-2 DCA FINAL-1 METRO-1 METRO-2 DCA TC-2 METRO-2 FINAL-2	DIRECT INTERCOM DIRECT COORDINATOR COORDINATOR COORDINATOR DIRECT DIRECT DIRECT	A C A A C C A C A	CENTER[2] CENTER[2] CENTER[2] CENTER[2] DCA TC-1 DCA TC-2	ADW FINAL-2 ADW FINAL-2 ADW FINAL-2 DCA FINAL-1 ADW FINAL-2 ADW FINAL-2
13	FINAL-1	FINAL APCH		PENETRATION FINALS				ADW FINAL-2 ADW TC-1	DIRECT DIRECT	A A	ADW TC-1	
14	FINAL-2	FINAL APCH		VECTORS TO FINAL (CONVENTIONAL AIRCRAFT)				ADW FINAL-1 ADW TC-2	DIRECT DIRECT	A A	ADW TC-2	
METRO DEPARTURES												
15	METRO-1	DCA/ADW DEP	(DCA)V123 (ADW)V123			RVD	40-	DCA TC-1	INTERCOM	B		CENTER CENTER
16	METRO-2	ADW DEP	V31 JETS			SOUTHEAST OF OTT	15	ADW TC-2	INTERCOM	B		CENTER CENTER
17	METRO-3	DCA/ADW DEP	(DCA)V8N (ADW)V8N			CROSSING DKS RVD CROSSING DKS	60+ 40 60+	 METRO-1 DCA TC-1	 DIRECT INTERCOM	 A B		CENTER CENTER CENTER
18	METRO-4	DCA/ADW DEP	(DCA)V140/V3 V140 (ADW)V140/V3 V140			WDB WDB CROSSING V223(S) RVD WDB RVD WDB CROSSING V223(S)	40- 40 60+ 40 40 40 40 60+	DCA TC-2 DCA TC-2 METRO-1 DCA TC-2 METRO-1 DCA TC-2	INTERCOM INTERCOM DIRECT INTERCOM DIRECT INTERCOM	B B A B A B		CENTER CENTER CENTER CENTER
19	RADAR HANDOFF (5 CONTROLLERS) RECEIVES RADAR HANDOFFS FROM CENTER FOR TRANSITION ARRIVAL CONTROLLER											

NOTE IN THIS CONFIGURATION ALL HANDOFFS FROM AND TO CENTER ACCOMPLISHED VIA HOT LINES

[1]PRIORITY

A - ESSENTIAL COORDINATION NEEDED

B - COORDINATION NEEDED TO EXPEDITE CLIMBS AND DESCENTS

C - COORDINATION NOT NORMALLY EFFECTED BUT WHICH COULD BE USED DURING PERIODS OF LIGHT TRAFFIC

[2]VIA RADAR HANDOFF CONTROLLER

FIG. 23 HANGAR 6 COORDINATION AND PROCEDURES - NORTH OPERATION (PHASES I AND II)

	POSITION	DESCRIPTION	DEPARTURE ROUTE	ARRIVAL		RESTRICTION		COORDINATION		PRIORITY[1]	HANDOFFS	
				ROUTE	FIX	POINT	ALTITUDE	NEEDED WITH	METHOD		FROM	TO
DULLES AIRPORT												
1	DDC-1	DEPARTURE	V223(S)			CLEAR OF HRN TSO UNTIL SOUTH OF V140	40- 50-	DCA TC-2 METRO-4	COORDINATOR DIRECT	C B		CENTER
2	DDC-2	DEPARTURE	V223(N) V92			CLEAR OF HRN TSO NORTH OF V8N WEST OF HRN TSO	40- 50 40	DCA TC-2 METRO-3 DCA TC-2	COORDINATOR DIRECT COORDINATOR	C B C		CENTER CENTER
3	TC-1	ARRIVALS		V8	CHT			TC-2 FINAL-1 TC-1	DIRECT DIRECT DIRECT	A A A	CENTER[2]	FINAL-1
4	TC-2	ARRIVALS		V174/V39	GLO	CROSSING DULLES DEP ROUTE TO V92	30-	DDC-2 TC-1 FINAL-2	DIRECT DIRECT DIRECT	A A A	CENTER[2]	FINAL-2
5	FINAL-1	FINAL APCH		VECTORS TO FINAL				FINAL-2 TC-1	DIRECT DIRECT	A A	TC-1	
6	FINAL-2	FINAL APCH		VECTORS TO FINAL				FINAL-1 TC-2	DIRECT DIRECT	A A	TC-2	
WASHINGTON AIRPORT												
7	TC-1	ARRIVALS		(DCA)V3 (ADW)V3	AIT AIT	ENTERING V123	30-	FINAL-1 ADW FINAL-2 METRO-1	DIRECT COORDINATOR INTERCOM	A A C	CENTER[2] CENTER[2]	FINAL-1 ADW FINAL-2
8	TC-2	ARRIVALS		(DCA)V4 (ADW)V4 (DCA)V157	HRN HRN DAH	CROSS HRN OVER ADW AIRPORT NORTH OF V140	50 70 50	DDC-2 FINAL-2 ADW TC-2 METRO-4 FINAL-2	COORDINATOR DIRECT DIRECT INTERCOM DIRECT	C A A B A	CENTER[2] CENTER[2] CENTER[2]	FINAL-2 ADW TC-2 FINAL-2
9	FINAL-1	FINAL APCH		VECTORS TO FINAL				FINAL-2 TC-1	DIRECT DIRECT	A A	TC-1	
10	FINAL-2	FINAL APCH		VECTORS TO FINAL				FINAL-1 TC-2	DIRECT DIRECT	A A	TC-2	
ANDREWS AIRPORT												
11	TC-1	ARRIVALS		PENETRATIONS	NHK BRV	STANDARD PENETRATION		FINAL-1 FINAL-1	DIRECT DIRECT	A A	CENTER[2] CENTER[2]	FINAL-1 FINAL-1
12	TC-2	ARRIVALS		V33 (ADW) V16 (DCA) V16 V4	CPE KTI KTI HRN	NORTH OF OTT WEST OF ADW ILS CROSSING ADW	25 50 70	METRO-2 FINAL-2 FINAL-2 DCA TC-2 DCA TC-2 FINAL-2	INTERCOM DIRECT DIRECT DIRECT DIRECT DIRECT	C A A A A A	CENTER[2] CENTER[2] CENTER[2] DCA TC-2	FINAL-2 FINAL-2 DCA TC-2 FINAL-2
13	FINAL-1	FINAL APCH		PENETRATION FINALS				TC-1 FINAL-2	DIRECT DIRECT	A A	TC-1	
14	FINAL-2	FINAL APCH		VECTORS TO FINAL (CONVENTIONAL ACFT)				TC-2 FINAL-1	DIRECT DIRECT	A A	TC-2	
METRO DEPARTURES												
15	METRO-1	DCA/ADW DEP	V123			[illegible]	[illegible]	DCA TC-[illegible]	INTERCOM	B		CENTER
16	METRO-2	ADW DEP	V31 JETS			SOUTHEAST OF OTT	15	ADW TC-2	INTERCOM	B		CENTER CENTER
17	METRO-3	DCA/ADW DEP	(DCA) V8N (ADW) V8N			CROSSING DKS CROSSING DKS	60+ 60+	METRO-1	DIRECT			CENTER CENTER
18	METRO-4	DCA/ADW DEP	DCA V140/V3 ADW V140/V3			WDB WDB CROSSING V223S	40- 40 60+	DCA TC-2 METRO-1 DCA TC-2	INTERCOM DIRECT INTERCOM	B A B		CENTER CENTER
19	RADAR HANDOFF (5 CONTROLLERS) RECEIVES RADAR HANDOFFS FROM CENTER FOR TRANSITION ARRIVAL CONTROLLERS											

NOTE: IN THIS CONFIGURATION ALL HANDOFFS FROM AND TO CENTER ACCOMPLISHED VIA HOT LINES.

[1]PRIORITY:

A - ESSENTIAL COORDINATION NEEDED.

B - COORDINATION NEEDED TO EXPEDITE CLIMBS AND DESCENTS.

C - COORDINATION NOT NORMALLY EFFECTED BUT WHICH COULD BE USED DURING PERIODS OF LIGHT TRAFFIC.

[2]VIA RADAR HANDOFF CONTROLLER.

FIG. 24 HANGAR 6 COORDINATION AND PROCEDURES - SOUTH OPERATION (PHASE I)

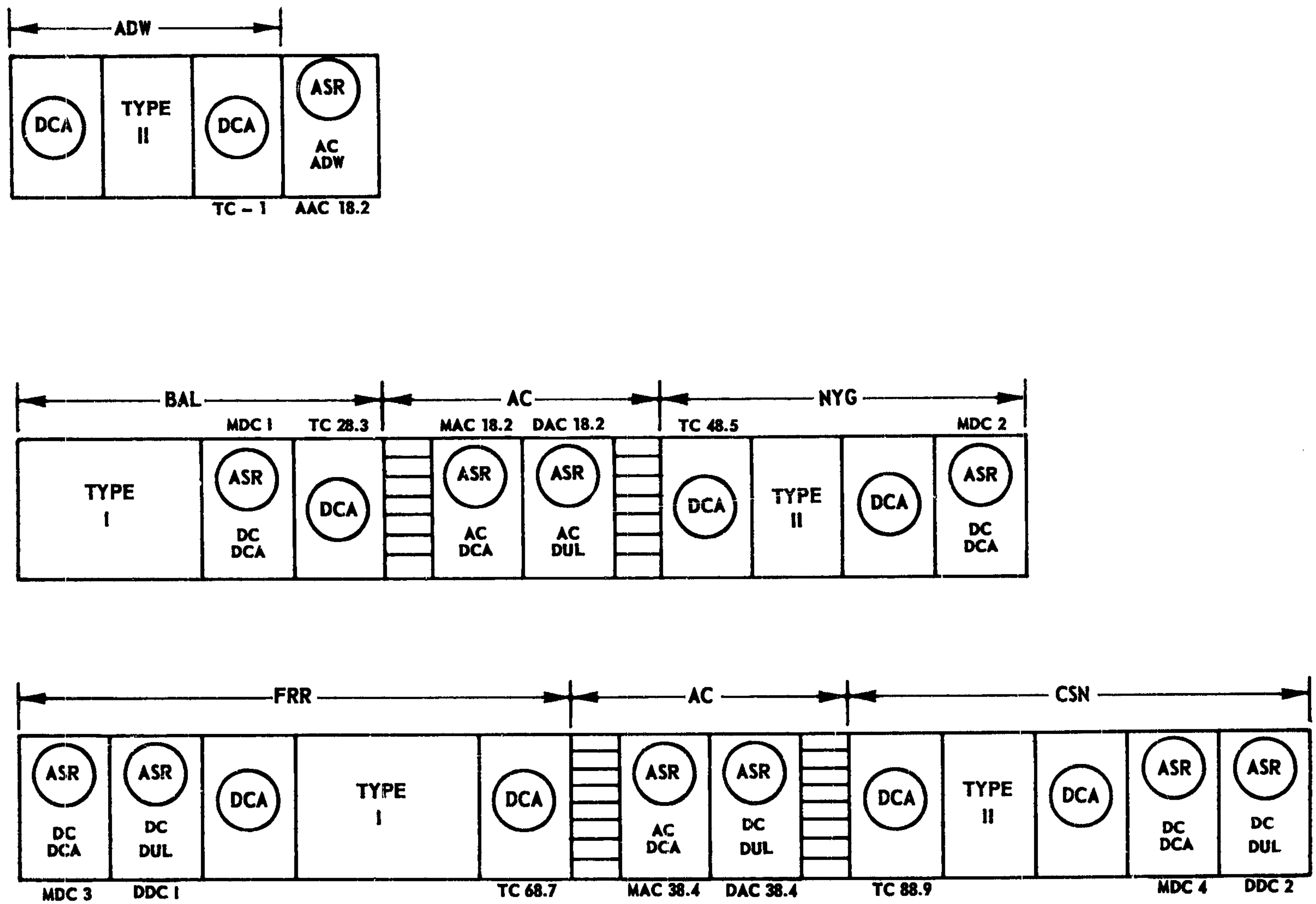


FIG. 25 IN-LINE ORIGINAL EQUIPMENT CONFIGURATION (SKETCH)

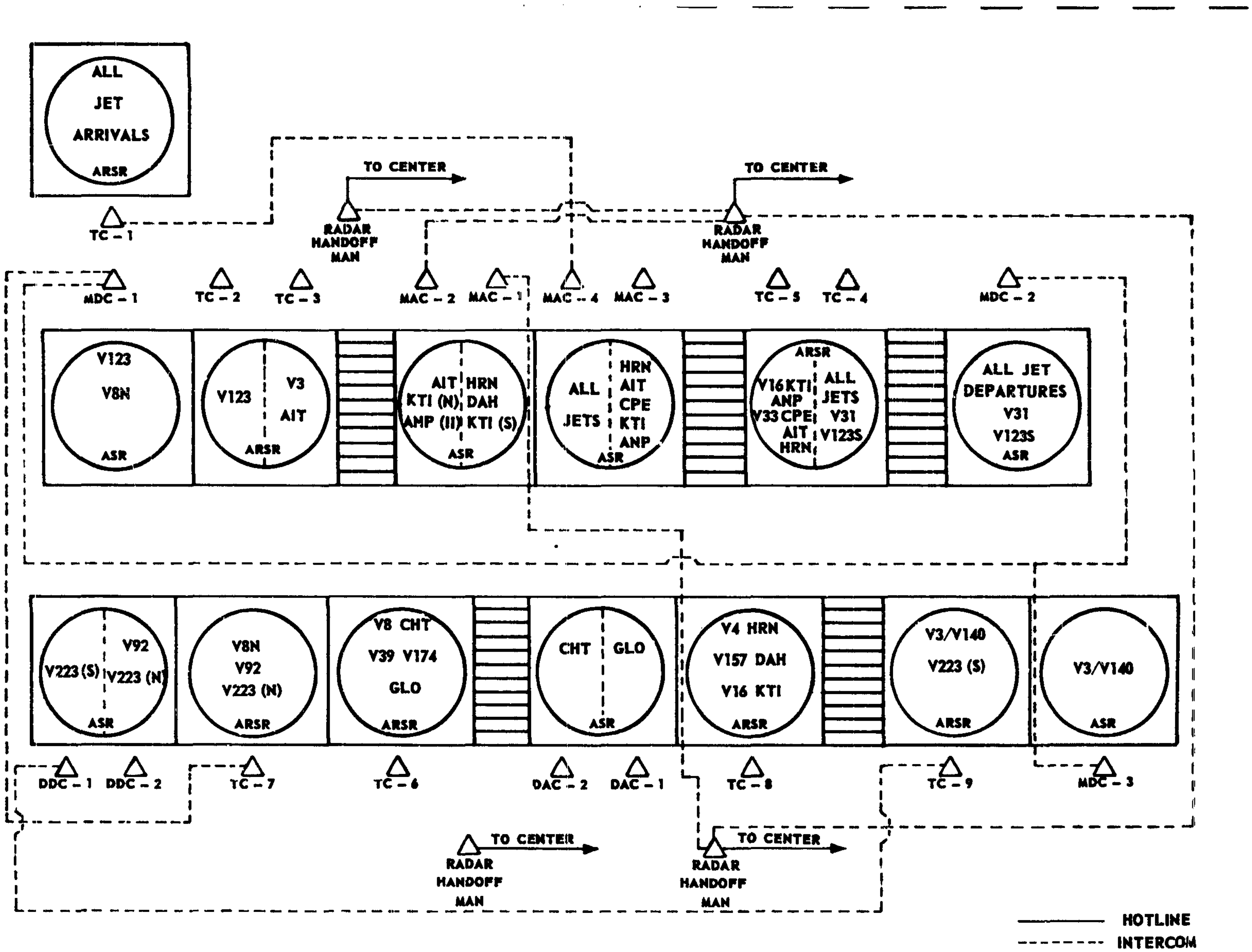


FIG. 26 IN-LINE MODIFIED EQUIPMENT CONFIGURATION (SKETCH)

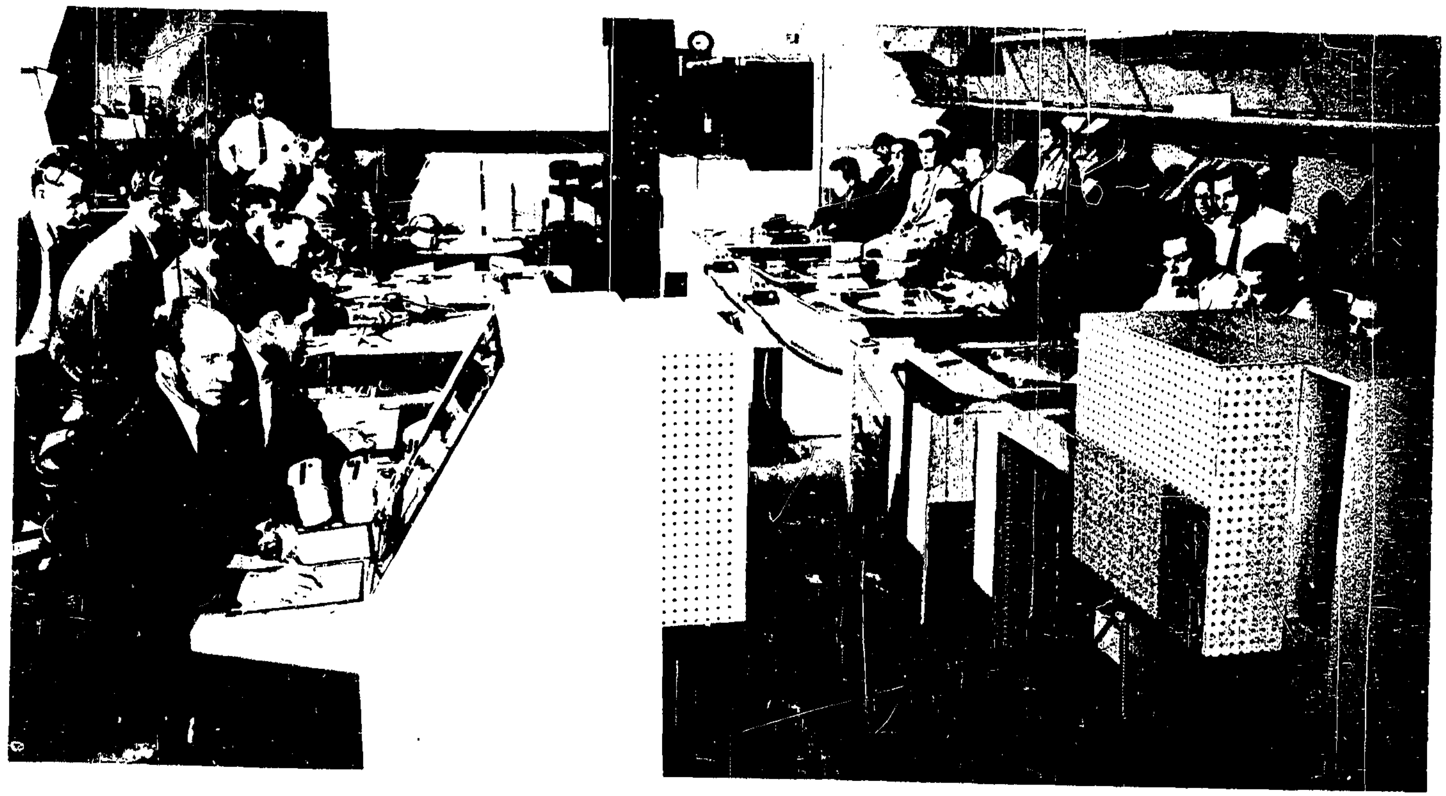


FIG. 27 IN-LINE MODIFIED EQUIPMENT CONFIGURATION

	POSITION	DESCRIPTION	DEPARTURE ROUTE	ARRIVAL ROUTE	ARRIVAL FIX	RESTRICTION POINT	RESTRICTION ALTITUDE	COORDINATION NEEDED WITH	COORDINATION METHOD	PRIORITY[1]	HANDOFFS FROM	HANDOFFS TO
1	TC-1	ADW JET ARR		PENETRATION	NHK	STANDARD PENETRATION		MAC-4	INTERCOM	A	CENTER[2]	MAC-4
					BRV	STANDARD PENETRATION		MAC-4	INTERCOM	A	CENTER[2]	MAC-4
2.	TC-2	DCA/ADW TRANSITION DEPARTURE	V123								MDC-1	CENTER[3]
3.	TC-3	DCA/ADW TRANSITION ARRIVAL		(DCA) V3	AIT	SOUTH OF RVD	50	MDC-1	DIRECT	C	CENTER[3]	MAC-2
				(ADW) V3	AIT	SOUTH OF RVD	50	MDC-1	DIRECT	C	CENTER[3]	TC-5
								MAC-2	DIRECT	A		
								TC-5	INTERCOM	A		
4.	TC-4	ADW DEP	JETS AND (CONV) V31					MDC-2	DIRECT	A	MDC-2	CENTER[3]
											MDC-2	CENTER[3]
5.	TC-5	ADW/DCA TRANSITION ARRIVAL		(ADW) V33	CPE			MAC-3	DIRECT	A	CENTER[3]	MAC-3
				(ADW) V16	KTI	SOUTHWEST OF V31	25	TC-4	DIRECT	C	CENTER[3]	MAC-3
				(DCA) V16	KTI	UNTIL WEST ADW ILS	50	MAC-2	INTERCOM	A	CENTER[3]	MAC-2
				(ADW) V3	AIT	SOUTH OF RVD	50	MDC-1	COORDINATOR	C	TC-3	
						CROSSING OTT	25+	TC-4	DIRECT	C		MAC-3
				(ADW) V4	HRN	CROSSING ADW	70	TC-8	INTERCOM	A	TC-8	
						CROSSING OTT	25+	TC-4	DIRECT	C		MAC-3
6.	TC-6	DULLES TRANSITION ARRIVAL		V8	CHT	CROSSING V92	30+	DDC-2	COORDINATOR[4]	B	CENTER[3]	
						ENTERING V4	40-	TC-8	COORDINATOR[4]	C		
								DAC-2	DIRECT	A		DAC-2
				V174/V39	GLD			DAC-1	DIRECT	A	CENTER[3]	DAC-1
7.	TC-7	DCA/ADW/DUL TRANSITION DEPARTURE	(DCA/ADW)V8N			DKS	60+	MDC-1	INTERCOM	A	MDC-1	CENTER[3]
			(DUL)V223(N)			DKS	50-	DDC-2	DIRECT	A	DDC-2	CENTER[3]
			(DUL)V92								DDC-2	CENTER[3]
8.	TC-8	DCA/ADW TRANSITION ARRIVAL		(DCA) V4	HRN	SOUTH OF V140	50	MDC-3	COORDINATOR[4]	C	CENTER[3]	MAC-1
								MAC-1	INTERCOM	A		
				(ADW) V4	HRN	OVER ADW AIRPORT	70	TC-5	INTERCOM	A		TC-5
				(DCA) V157	DAH			MAC-1	INTERCOM	A	CENTER[3]	MAC-1
9.	TC-9	DCA/ADW/DUL TRANSITION DEPARTURE	DCA/ADW V140			CROSSING V223(S)	60+	MDC-3	DIRECT	A	MDC-3	CENTER[3]
			DCA/ADW V3								MDC-3	CENTER[3]
			DULLES V223(S)			UNTIL SOUTH V140	50	DDC-1	INTERCOM	A	DDC-1	CENTER[3]
10.	MAC-1	FINAL APCH (DCA)		VECTORS TO FINAL APPROACH				TC-8	INTERCOM	A	TC-8	
								MAC-2	DIRECT	A		
11.	MAC-2	FINAL APCH (DCA)		VECTORS TO FINAL APPROACH				TC-3	DIRECT	A	TC-3	
								MAC-1	DIRECT	A		
								TC-5	COORDINATOR[4]	A	TC-5	
12.	MAC-3	FINAL APCH (ADW)		VECTORS TO FINAL APPROACH				TC-5	DIRECT	A	TC-5	
								MAC-4	DIRECT	A		
13.	MAC-4	FINAL APCH (ADW)		PENETRATION FINAL				TC-1	INTERCOM	A	TC-1	
								MAC-3	DIRECT	A		
14.	MDC-1	DCA/ADW DEP.	(DCA) V123			RVD	40-	TC-3	DIRECT	B		TC-2
								TC-2	DIRECT	A		
			(ADW) V123					TC-2	DIRECT	A		TC-2
			(DCA) V8N					TC-7	INTERCOM	A		TC-7
			(ADW) V8N			RVD	40	TC-3	DIRECT	B		TC-7
15.	MDC-2	ADW DEP.	ALL JETS			NONE		TC-4	DIRECT			TC-4
			& V31 (CONV)			SOUTHEAST OTT	15	TC-5	DIRECT	B		TC-4
16.	MDC-3	DCA/ADW DEP.	(DCA) V140/V3			WDB	40-	TC-8	COORDINATOR[4]	B		TC-9
								TC-9	DIRECT	A		
			(DCA) V140			WDB	40-	TC-8	COORDINATOR[4]	B		TC-9
								TC-9	DIRECT	A		
			(ADW) V140/V3			RVD	40	MDC-1	INTERCOM	B		
						WDB	40	TC-8	COORDINATOR[4]	B		TC-9
17.	DDC-2	DUL. DEP.	V223(N)			CLEAR OF HRN TSO	40-	TC-8	COORDINATOR[4]	C		TC-7
			V92			WEST OF CHT ARRIVAL						
						VECTORING PATH	20-	TC-6	DIRECT	B		
						CLEAR OF HRN TSO	40	TC-8	COORDINATOR[4]	C		TC-7
								TC-7	DIRECT	A		
18.	DDC-1	DULLES DEP.	V223(S)			CLEAR OF HRN TSO	40	TC-8	COORDINATOR[4]	C		
								TC-9	INTERCOM	A		TC-9
19.	DAC-1	FINAL APCH (DULLES)		VECTORS TO FINAL APPROACH				TC-6	DIRECT	A	TC-6	
								DAC-2	DIRECT	A		
20.	DAC-2	FINAL APCH (DULLES)		VECTORS TO FINAL APPROACH				TC-6	DIRECT	A	TC-6	
								DAC-1	DIRECT	A		
21.	RADAR HANDOFF (4 CONTROLLERS) RECEIVES AND EFFECTS HANDOFFS FOR ASSOCIATED TRANSITION ARRIVAL CONTROLLER.											

[1]PRIORITY

A - ESSENTIAL COORDINATION NEEDED.

B - COORDINATION NEEDED TO EXPEDITE CLIMBS AND DESCENTS.

C - COORDINATION NOT NORMALLY EFFECTED BUT WHICH COULD BE USED DURING PERIODS OF LIGHT TRAFFIC.

[2]HANDOFFS FROM CENTER VIA DIRECT METHOD.

[3]HANDOFFS FROM CENTER VIA "HOT LINE".

[4]ORIGINAL PLANS FOR IN-LINE CONFIGURATION INDICATED NO COORDINATORS. THIS COORDINATION COULD BE ACCOMPLISHED BY INTERPHONE OR COORDINATOR.

FIG. 28 IN-LINE COORDINATION AND PROCEDURES - NORTH OPERATION (PHASES I AND II)

	POSITION	DESCRIPTION	DEPARTURE ROUTE	ARRIVAL ROUTE	ARRIVAL FIX	RESTRICTION POINT	RESTRICTION ALTITUDE	COORDINATION NEEDED WITH	COORDINATION METHOD	PRIORITY[1]	HANDOFFS FROM	HANDOFFS TO
1.	TC-1	ADW ARRIVALS (JETS)		PENETRATION	BAL	STANDARD PENETRATION		MAC-4	INTERCOM	A	CENTER[2]	MAC-4
2.	TC-2	DCA/ADW TRANSITION DEPARTURE	V123								MDC-1	CENTER[3]
3.	TC-3	DCA/ADW TRANSITION ARRIVAL		(DCA) V3 (ADW)V3	AIT AIT	ENTERING V123	30-	MAC-2 MAC-3 MDC-1	DIRECT COORDINATOR[4] DIRECT	A A C	CENTER[3]	MAC-2
4.	TC-4	ADW TRANSITION DEPARTURE	JETS AND (CONV) V31					MDC-2	DIRECT	A		CENTER[3] CENTER[3]
5.	TC-5	ADW/DCA TRANSITION ARRIVAL		(ADW)V33 (ADW) V16 (DCA) V16 (ADW) V4	CPE KTI KTI HRN	NORTH OF OTT WEST OF ADW ILS OVER ADW AIRPORT	25 50 70	MDC-2 MAC-3 MAC-3 TC-8 TC-8	DIRECT DIRECT DIRECT INTERCOM INTERCOM	B A A A A	CENTER[3] CENTER[3] TC-8	MAC-3 MAC-3 TC-8 MAC-3
6.	TC-6	DULLES TRANSITION ARRIVAL		V8 V174/V39	CHT GLO	CROSSING DULLES DEP. ROUTE TO V92	30-	DAC-2 DDC-2 DAC-1	DIRECT COORDINATOR[4] DIRECT	A A A	CENTER[3] CENTER[3]	DAC-2 DAC-1
7.	TC-7	DUL/DCA/ADW TRANSITION DEPARTURE	DCA/ADW V8N (DUL)V223(N) (DUL) V92			DKS DKS	60- 50-	MDC-1 DDC-2	INTERCOM DIRECT	A A	MDC-1 DDC-2	CENTER[3] CENTER[3]
8.	TC-8	DCA/ADW TRANSITION ARRIVAL		(DCA) V4 (ADW) V4 (DCA) V157 (DCA) V16	HRN HRN DAH KTI	CROSS HRN OVER ADW AIRPORT NORTH OF V140 WEST OF ADW ILS	50 70 50 50	MAC-1 TC-5 MDC-3 MAC-1 TC-5	INTERCOM INTERCOM COORDINATOR[4] INTERCOM INTERCOM	A A C A A	CENTER[3] CENTER[3] CENTER[3] TC-5	MAC-1 TC-5 MAC-1 MAC-1
9.	TC-9	DCA/ADW/DUL TRANSITION DEPARTURE	DCA/ADW V140 DCA/ADW V3 DUL V223(S)			CROSSING V223(S) SOUTH OF V140	60+ 50	MDC-3 MDC-3 DDC-1	DIRECT DIRECT INTERCOM	A A A	MDC-3 MDC-3 DDC-1	CENTER[3] CENTER[3] CENTER[3]
10.	MAC-1	FINAL APCH (DCA)		VECTORS TO FINAL APPROACH				TC-8 MAC-2	INTERCOM DIRECT	A A	TC-8	
11.	MAC-2	FINAL APCH (DCA)		VECTORS TO FINAL APPROACH				TC-3 MAC-1	DIRECT DIRECT	A A	TC-3	
12.	MAC-3	FINAL APCH (ADW)		VECTORS TO FINAL APPROACH				TC-5 MAC-4	DIRECT DIRECT	A A	TC-5	
13.	MAC-4	FINAL APCH (ADW)		PENETRATION FINAL				TC-1 MAC-3	INTERCOM DIRECT	A A	TC-1	
14.	MDC-1	DCA/ADW DEP.	(DCA/ADW)V123 (DCA) V8N (ADW) V8N			RVD	40	TC-2 TC-7 TC-7 MDC-3	DIRECT INTERCOM INTERCOM INTERCOM	A A A A		TC-2 TC-7 TC-7
15.	MDC-2	ADW DEP.	ALL JETS V31 (CONV)			NONE SOUTHEAST OF OTT	15	TC-5 TC-4	DIRECT DIRECT	B A		TC-4
16.	MDC-3	DCA/ADW DEP.	(DCA) V140/V3 (ADW) V140/V3			WDB	40	TC-8 TC-9 MDC-1	COORDINATOR[4] DIRECT INTERCOM	B A A		TC-9
17.	DDC-2	DULLES DEP.	V223N V92			CLEAR OF HRN TSO WEST OF HRN TSO	40 40	TC-8 TC-8 TC-7	COORDINATOR[4] COORDINATOR[4] DIRECT	C C A		TC-7 TC-7
18.	DDC-1	DULLES DEP.	V223(S)			CLEAR OF HRN TSO	40-	TC-8 TC-9	COORDINATOR[4] INTERCOM	C A		TC-9
19.	DAC-1	FINAL APCH (DULLES)		VECTORS TO FINAL APPROACH				TC-6 DAC-2	DIRECT DIRECT	A A	TC-6	
20.	DAC-2	FINAL APCH (DULLES)		VECTORS TO FINAL APPROACH				TC-6 DAC-1	DIRECT DIRECT	A A	TC-6	
21	RADAR HANDOFF (4 CONTROLLERS) RECEIVES AND EFFECTS HANDOFFS FOR ASSOCIATED TRANSITION ARRIVAL CONTROLLER.											

[1]PRIORITY

A - ESSENTIAL COORDINATION NEEDED.

B - COORDINATION NEEDED TO EXPEDITE CLIMBS AND DESCENTS.

C - COORDINATION NOT NORMALLY EFFECTED BUT WHICH COULD BE USED DURING PERIODS OF LIGHT TRAFFIC.

[2]HANDOFFS FROM CENTER VIA DIRECT METHOD.

[3]HANDOFFS FROM CENTER VIA HOT LINE.

[4]ORIGINAL PLANS FOR IN-LINE CONFIGURATION INDICATED NO COORDINATORS. THIS COORDINATION COULD BE ACCOMPLISHED BY INTERPHONE OR COORDINATOR.

FIG. 29 IN-LINE COORDINATION AND PROCEDURES - SOUTH OPERATION (PHASE I)

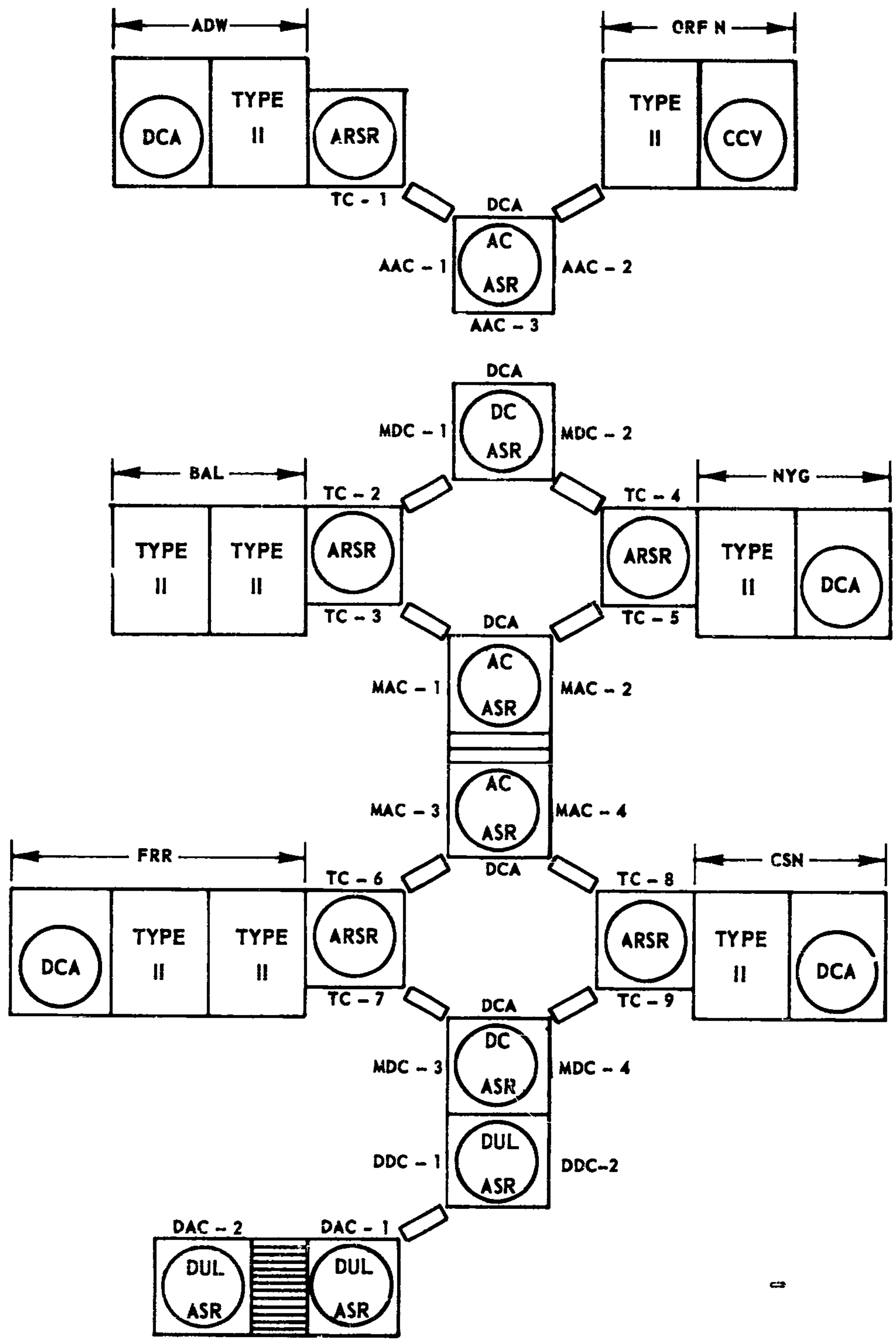


FIG. 30 BUTTERFLY ORIGINAL EQUIPMENT CONFIGURATION (SKETCH)

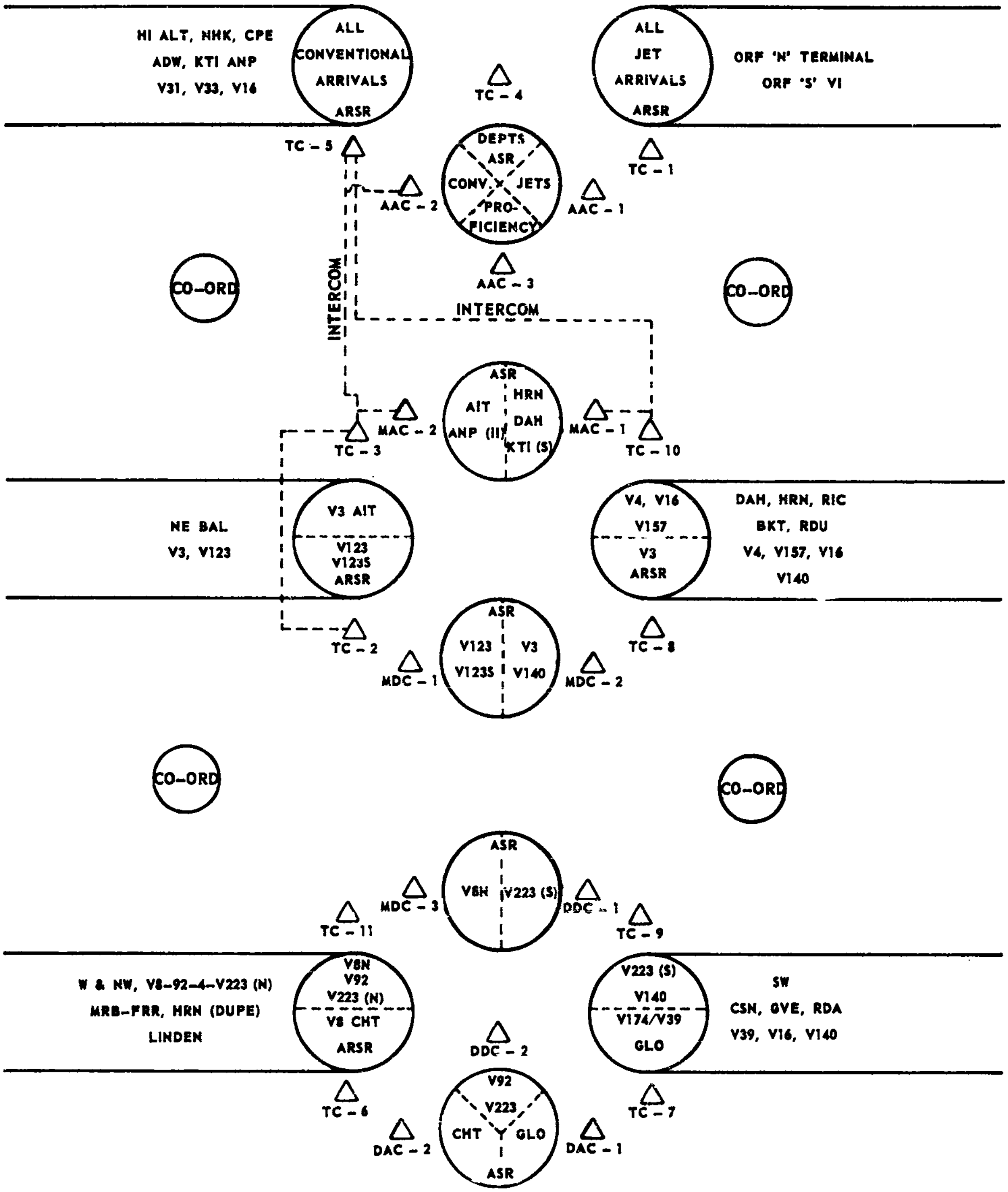
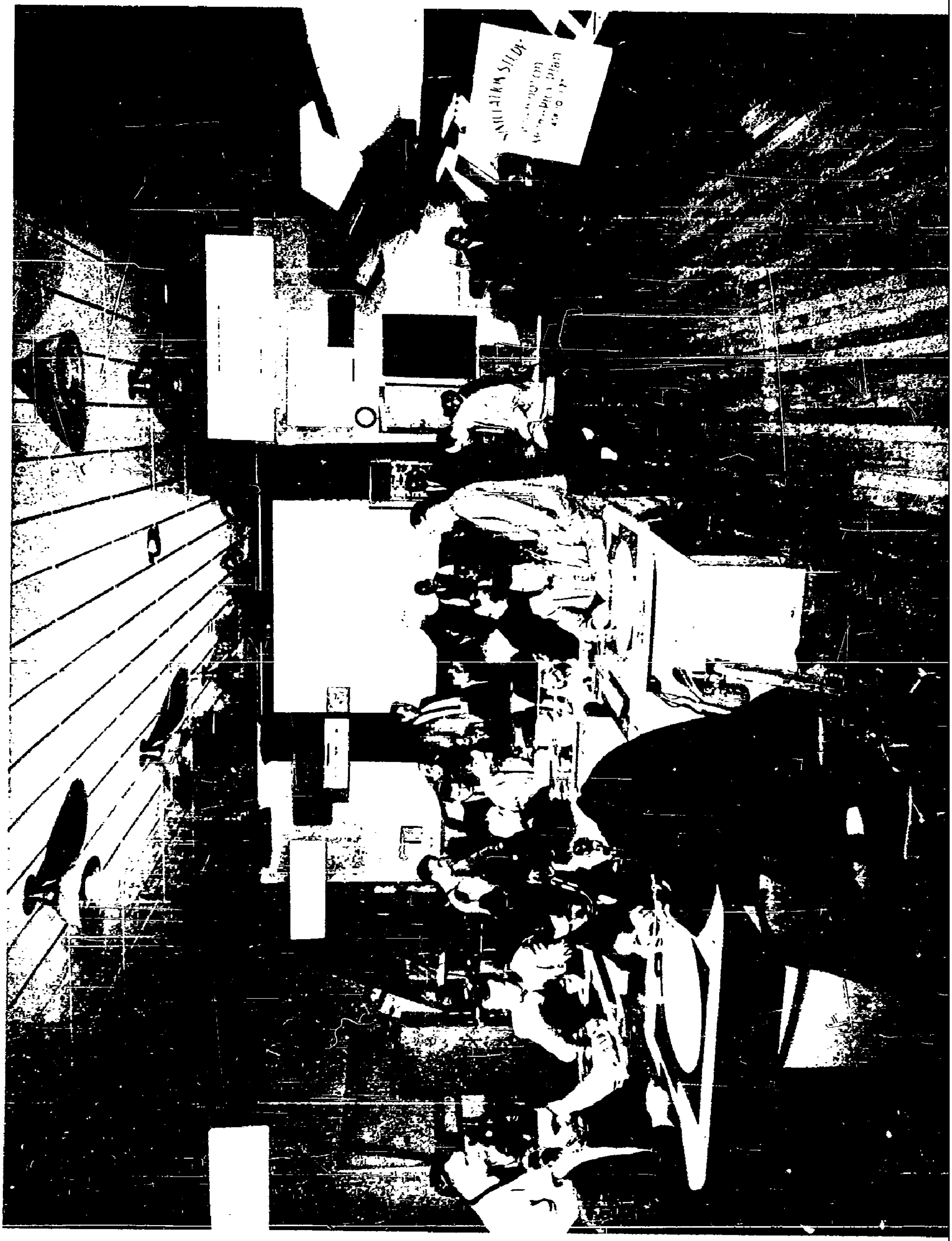


FIG. 31 BUTTERFLY MODIFIED EQUIPMENT CONFIGURATION (SKETCH)



	POSITION	DESCRIPTION	DEPARTURE ROUTE	ARRIVAL ROUTE	ARRIVAL FIX	RESTRICTION POINT	RESTRICTION ALTITUDE	COORDINATION NEEDED WITH	COORDINATION METHOD	PRIORITY[1]	HANDOFFS FROM	HANDOFFS TO
1.	TC-1	ADW ARRIVALS (JET)		PENETRATIONS	NHK BRV	STANDARD PENETRATIONS STANDARD PENETRATIONS		AAC-1 AAC-1	DIRECT DIRECT	A A	CENTER[2] CENTER[2]	AAC-1 AAC-1
2.	TC-2	DCA/ADW TRANSITION DEPARTURE	(DCA) V123 (ADW)								MDC-1 MDC-1	CENTER[2] CENTER[2]
3.	TC-3	DCA/ADW TRANSITION ARRIVAL		(DCA) V3 (ADW) V3	AIT AIT	SOUTH OF RVD SOUTH OF RVD	50 50	MDC-1 MDC-1 MAC-2 TC-5	DIRECT DIRECT DIRECT INTERCOM	C C A A	CENTER[2] CENTER[2]	MAC-2 TC-5
4.	TC-4	ADW TRANSITION DEPARTURE	ALL JETS V31			NONE SOUTHEAST OF OTT	15	TC-5	DIRECT	B		CENTER[2] CENTER[2]
5.	TC-5	DCA/ADW TRANSITION ARRIVAL (CONV)		V33 (ADW) V16 (DCA) V16 (ADW) V3 V4	CPE KTI KTI AIT HRN	SOUTHWEST OF V31 UNTIL WEST ADW ILS RVD CROSSING OTT CROSSING ADW CROSSING OTT	25 50 50 25- 70 25+	AAC-2 TC-4 MAC-2 MDC-1 TC-4 TC-10 TC-4	DIRECT DIRECT INTERCOM COORDINATOR DIRECT INTERCOM DIRECT	A C A C C A C	CENTER[2] CENTER[2] CENTER[2] DCA TC-3 DCA TC-10	AAC-2 AAC-2 MAC-2 AAC-2 AAC-2
6.	TC-6	DULLES TRANSITION ARRIVAL		V8	CHT	CROSSING V92 ENTERING V4	30+ 40-	DDC-2 TC-10 TC-7 DAC-2	DIRECT COORDINATOR DIRECT DIRECT	B C A A	CENTER[2]	DAC-2
7.	TC-7	DULLES TRANSITION ARRIVAL		V174/V39	GLO			TC-6 DAC-1	DIRECT DIRECT	A A	CENTER[2] CENTER[2]	DAC-1
8.	TC-8	DCA/ADW TRANSITION DEPARTURE	V3								MDC-2	CENTER[2]
9.	TC-9	DULLES/ DCA/ ADW TRANSITION DEPARTURE	V223(S) (DCA/ADW)V140			UNTIL SOUTH V140 CROSSING V223(S)	50 60+	DDC-1 MDC-2	DIRECT COORDINATOR	A A	DDC-1 MDC-2	CENTER[2] CENTER[2]
10.	TC-10	DCA/ADW TRANSITION ARRIVAL		(DCA) V4 (ADW) V4 (DCA) V157	HRN HRN DAH	SOUTH OF V140 OVER ADW ARPT.	50 70	MDC-2 TC-5 MAC-1	COORDINATOR INTERCOM DIRECT	B A A	CENTER[2] CENTER[2]	MAC-1 TC-5 MAC-1
11.	TC-11	DULLES/DCA/ ADW TRANSITION DEPARTURE	DCA/ADW V8N (DUL) V223(N) (DUL) V92			DKS DKS	60+ 50-	MDC-3 DDC-2	DIRECT DIRECT	A A	MDC-3 DDC-2 DDC-2	CENTER[2] CENTER[2] CENTER[2]
12.	MAC-1	FINAL APCH DCA		VECTORS TO FINAL APPROACH				TC-10 MAC-2	DIRECT DIRECT	A A	DCA TC-10	
13.	MAC-2	FINAL APCH DCA		VECTORS TO FINAL APPROACH				TC-3 MAC-1	DIRECT DIRECT	A A	DCA TC-3	
14.	DAC-1	FINAL APCH DULLES		VECTORS TO FINAL APPROACH				TC-7 DAC-2	DIRECT DIRECT	A A	TC-7	
15.	DAC-2	FINAL APCH DULLES		VECTORS TO FINAL APPROACH				TC-6 DAC-1	DIRECT DIRECT	A A	TC-6	
16.	AAC-1	FINAL APCH ADW (JETS)		PENETRATION FINALS				TC-1 AAC-2	DIRECT DIRECT	A A	TC-1	
17.	AAC-2	FINAL APCH ADW (CONV)		VECTORS TO FINAL APPROACH				TC-5 AAC-1	DIRECT DIRECT	A A	TC-5	
18.	MDC-1	DCA/ADW DEP.	(DCA) V123 (ADW) V123			RVD	40-	TC-3 TC-2 TC-2	COORDINATOR DIRECT DIRECT	B A A		TC-2 TC-2
19.	MDC-2	DCA/ADW DEP.	(DCA) V140/V3 (DCA) V140 (ADW) V140/V3 (ADW) V140			WDB WDB RVD WDB RVD WDB	40- 40- 40 40 40 40	TC-10 TC-8 TC-10 TC-9 MDC-1 TC-10 MDC-1 TC-10	COORDINATOR DIRECT COORDINATOR COORDINATOR DIRECT COORDINATOR DIRECT COORDINATOR	B A B A A B A B		TC-5 TC-9 TC-8 TC-9
20.	MDC-3	DCA/ADW DEP.	(DCA) V8N (ADW) V8N			RVD	40	TC-11 MDC-1 TC-3	DIRECT DIRECT COORDINATOR	A A B		TC-11 TC-11
21.	DDC-1	DULLES DEP.	V223(S)			CLEAR OF HRN TSO	40-	TC-10	COORDINATOR	C		TC-9
22.	DDC-2	DULLES DEP.	V223(N) V92			CLEAR OF HRN TSO WEST OF CHT ARRIVAL VECTORING PATH CLEAR OF HRN TSO	40- 20- 40-	TC-10 TC-6 TC-10	COORDINATOR DIRECT COORDINATOR	C B C		TC-11 TC-11
23.	RADAR HANDOFF (5 CONTROLLERS) RECEIVES RADAR HANDOFFS FROM CENTER SECTORS FOR TRANSITION ARRIVAL CONTROLLERS.											

[1]PRIORITY

A - ESSENTIAL COORDINATION NEEDED.

B - COORDINATION NEEDED TO EXPEDITE CLIMBS AND DESCENTS.

C - COORDINATION NOT NORMALLY EFFECTED BUT WHICH COULD BE USED IN PERIODS OF LIGHT TRAFFIC.

[2]HANDOFF TO AND FROM CENTER VIA DIRECT METHOD.

FIG. 33 BUTTERFLY COORDINATION AND PROCEDURES - NORTH OPERATION (PHASES I AND II)

	POSITION	DESCRIPTION	DEPARTURE ROUTE	ARRIVAL		RESTRICTION		COORDINATION		PRIORITY[1]	HANDOFFS	
				ROUTE	FIX	POINT	ALTITUDE	NEEDED WITH	METHOD		FROM	TO
1.	TC-1	ADW ARRIVALS (JET)		PENETRATIONS	BAL	STANDARD PENETRATION		AAC-1	DIRECT	A	CENTER[2]	AAC-1
2.	TC-2	DCA/ADW TRANSITION DEPARTURE	(DCA) V123 (ADW)								MDC-1 MDC-1	CENTER[2] CENTER[2]
3.	TC-3	DCA/ADW TRANSITION ARRIVAL		(DCA)V3 (ADW)V3	AIT AIT	ENTERING V123	30-	MAC-2 AAC-2 MDC-1	DIRECT INTERCOM COORDINATOR	A A C	CENTER[2] CENTER[2]	MAC-2 AAC-2
4.	TC-4	ADW TRANSITION DEPARTURE	ALL JETS V31			NONE SOUTHEAST OF OTT	15	TC-5	DIRECT	B		CENTER[2] CENTER[2]
5.	TC-5	DCA/ADW TRANSITION ARRIVAL (CONV)		(ADW)V33 (ADW)V16 (DCA)V16 (ADW)V4	CPE KTI KTI HRN	NORTH OF OTT WEST OF ADW ILS OVER ADW AIRPORT	25 50 70	TC-4 AAC-2 AAC-2 TC-1J TC-10	DIRECT DIRECT DIRECT INTERCOM INTERCOM	B A A A A	CENTER[2] CENTER[2] TC-10	AAC-2 AAC-2 TC-10 AAC-2
6.	TC-6	DULLES TRANSITION ARRIVAL		V8	CHT			DAC-2 TC-7	DIRECT DIRECT	A A	CENTEP[2]	DAC-2
7.	TC-7	DULLES TRANSITION ARRIVAL		V174/V39	GLO	CROSSING DULLES DEP. ROUTE TO V92	30-	DDC-2 TC-6 DAC-1	DIRECT DIRECT DIRECT	A A A	CENTER[2]	DAC-1
8.	TC-8	DCA/ADW TRANSITION DEPARTURE	WDB V3					MDC-2	DIRECT	A	MDC-2	CENTER[2]
9.	TC-9	DULLES/DCA/ ADW TRANSITION DEPARTURE	V223(S) (DCA) (ADW)V140			SOUTH OF V140 CROSSING V223(S)	50 60+	DDC-1 MDC-2	DIRECT COORDINATOR		DDC-1 MDC-2	CENTER[2] CENTER[2]
10.	TC-10	DCA/ADW TRANSITION ARRIVAL		(DCA)V4 (ADW)V4 (DCA)V157 V16	HRN HRN DAH KTI	CROSS HRN OVER ADW AIRPORT NORTH OF V140	50 70 50	DDC-2 MAC-2 TC-5 MDC-2 MAC-1	COORDINATOR DIRECT INTERCOM COORDINATOR DIRECT	C A A B A	CENTER[2] CENTER[2] CENTER[2]	MAC-1 TC-5 MAC-1
11.	TC-11	DULLES/DCA/ ADW TRANSITION DEPARTURE	(DCA/ADW)V8N (DUL)V223(N) (DUL)V92			DKS DKS	60+ 50-	MDC-3 DDC-2	DIRECT DIRECT		MDC-3 DDC-2 DDC-2	CENTER[2] CENTER[2] CENTER[2]
12.	MAC-1	FINAL APCH (DCA)		VECTORS TO FINAL APPROACH				TC-10 MAC-2	DIRECT DIRECT	A A	TC-10	
13.	MAC-2	FINAL APCH (DCA)		VECTORS TO FINAL APPROACH				TC-3 MAC-1	DIRECT DIRECT	A A	TC-3	
14.	DAC-1	FINAL APCH (DUL)		VECTORS TO FINAL APPROACH				TC-7 DAC-2	DIRECT DIRECT	A A	TC-7	
15.	DAC-2	FINAL APCH (DUL)		VECTORS TO FINAL APPROACH				TC-6 DAC-1	DIRECT DIRECT	A A	TC-6	
16.	AAC-1	FINAL APCH (ADW) JETS		PENETRATION FINALS				TC-1 AAC-2	DIRECT DIRECT	A A	TC-1	
17.	AAC-2	FINAL APCH (ADW) CONV.		VECTORS TO FINAL APPROACH				TC-5 AAC-1	DIRECT DIRECT	A A	TC-5	
18.	MDC-1	DCA/ADW DEPARTURE	V123			RVD	40	TC-2	DIRECT	A		TC-2
19.	MDC-2	DCA/ADW DEPARTURE	V140/V3			WDB	40-	TC-10 MDC-1 TC-8 TC-9	DIRECT DIRECT DIRECT COORDINATOR	B A A A		TC-8 TC-9
20.	MDC-3	DCA/ADW DEPARTURE	V8N					MDC-1 MDC-2 TC-11	DIRECT DIRECT DIRECT	A A A		TC-11
21	DDC-1	DULLES DEPARTURE	V223(S)			CLEAR OF HRN TSO	40-	TC-10 TC-9	COORDINATOR DIRECT	C A		TC-9
22.	DDC-2	DULLES DEPARTURE	V223(N) V92			CLEAR OF HRN TSO WEST OF HRN TSO	40- 40	TC-10 TC-11 TC-10 TC-11	COORDINATOR DIRECT COORDINATOR DIRECT	C A C A		TC-11 TC-11
23.	RADAR HANDOFF (5 CONTROLLERS) RECEIVES RADAR HANDOFFS FROM CENTER SECTORS FOR TRANSITION ARRIVAL CONTROLLERS.											

[1]PRIORITY

A - ESSENTIAL COORDINATION NEEDED.

B - COORDINATION NEEDED TO EXPEDITE CLIMBS AND DESCENTS.

C - COORDINATION NOT NORMALLY EFFECTED BUT WHICH COULD BE USED DURING PERIODS OF LIGHT TRAFFIC.

[2]HANDOFF TO AND FROM CENTER VIA DIRECT METHOD.

FIG. 34 BUTTERFLY COORDINATION AND PROCEDURES - SOUTH OPERATION (PHASE I)

HANGAR 6

ALL POSITIONS OPERATIONALLY THE SAME AS PHASE I WITH THE FOLLOWING EXCEPTIONS:

	POSITION	DESCRIPTION	DEPARTURE ROUTE	ARRIVAL ROUTE	ARRIVAL FIX	RESTRICTION POINT	RESTRICTION ALTITUDE	COORDINATION NEEDED WITH	COORDINATION METHOD	PRIORITY[1]	HANDOFFS FROM	HANDOFFS TO
1.	METRO-1	DCA/ADW DEP.	(DCA)V123S (ADW)V123S			CROSS ADW VOR EAST OF OTT	35+ 15	METRO-3 & 4 ADW TC-2	DIRECT COORDINATOR	A B		CENTER[2] CENTER[2]
2.	ADW TC-2	DCA/ADW TRANSITION ARRIVAL		(DCA)V44 DIRECT (ADW)V1A	ANP HRN	RVD CLEAR OF V123S	50 70	DCA FINAL-1 MDC-1	COORDINATOR COORDINATOR	A B	CENTER[2] DCA TC-2	DCA FINAL-1 ADW FINAL-1
3.	DCA FINAL-1	FINAL APCH		VECTORS TO FINAL	FROM ANP	WEST EDGE OF V123	50	MDC-1 ADW TC-2	COORDINATOR COORDINATOR	B A	TC-2	

IN-LINE

ALL POSITIONS OPERATIONALLY THE SAME AS PHASE I WITH THE FOLLOWING EXCEPTIONS:

	POSITION	DESCRIPTION	DEPARTURE ROUTE	ARRIVAL ROUTE	ARRIVAL FIX	RESTRICTION POINT	RESTRICTION ALTITUDE	COORDINATION NEEDED WITH	COORDINATION METHOD	PRIORITY	HANDOFFS FROM	HANDOFFS TO
1.	MDC-1	DCA/ADW DEP.	V8N					MDC-2 TC-7	INTERCOM INTERCOM	A A		TC-7
2.	MDC-2	DCA/ADW DEP.	V123S (+V31 AND JETS)			(DCA)CROSS ADW VOR (ADW)EAST OF OTT	35+ 15	MDC-1 TC-4	INTERCOM DIRECT	A A		TC-4
3.	MAC-2	FINAL APCH (DCA)		VECTORS TO FINAL		WEST EDGE OF V123	50	MDC-1 TC-5	COORDINATOR INTERCOM	B A	TC-5	
4.	TC-5	DCA/ADW TRANSITION ARRIVAL		(DCA)V44 DIRECT (ADW)V1A	ANP HRN	RVD CLEAR OF V123S	50 70	MAC-2 TC-4	INTERCOM DIRECT	A B	CENTER[2] TC-8	MAC-2 MAC-3

BUTTERFLY

ALL POSITIONS OPERATIONALLY THE SAME AS PHASE I WITH THE FOLLOWING EXCEPTIONS:

	POSITION	DESCRIPTION	DEPARTURE ROUTE	ARRIVAL ROUTE	ARRIVAL FIX	RESTRICTION POINT	RESTRICTION ALTITUDE	COORDINATION NEEDED WITH	COORDINATION METHOD	PRIORITY	HANDOFFS FROM	HANDOFFS TO
1.	MDC-1	DCA/ADW DEP.	V123S			(DCA)CROSS ADW VOR (ADW)EAST OF OTT	35+ 15	MDC-2 MDC-2-3 TC-2	DIRECT DIRECT DIRECT	A A A		TC-2
2.	MAC-2	FINAL APCH (DCA)		VECTORS TO FINAL		WEST EDGE OF V123	50	MDC-1 TC-5	COORDINATOR INTERCOM	B A		TC-5
3.	TC-5	DCA/ADW TRANSITION ARRIVAL		(DCA)V44 DIRECT (ADW)V1A	ANP HRN	RVD CLEAR OF V123S	50 70	MAC-2 TC-2 TC-10	INTERCOM INTERCOM INTERCOM	A B A	CENTER[3] TC-10	MAC-2 AAC-2

[1] PRIORITY

A - ESSENTIAL COORDINATION NEEDED.

B - COORDINATION NEEDED TO EXPEDITE CLIMBS AND DESCENTS.

[2] HANDOFFS TO AND FROM CENTER VIA HOT LINE.

[3] HANDOFF FROM CENTER VIA DIRECT.

FIG. 35 ALL EQUIPMENT CONFIGURATIONS COORDINATION AND PROCEDURES - SOUTH OPERATION (PHASE II)

TEST RESULTS

Experimental Design

The purpose of the main simulation effort was to examine the effect on several measures of system performance, of two important variables: (1) equipment configurations, and (2) Andrews AFB climb corridor. In the planning for this simulation, it was determined that only these two variables should be evaluated in the time available for dynamic simulation. Three levels of the equipment configurations and two levels of the climb corridor condition were combined, resulting in six experimental conditions, as shown in Table II.

TABLE II

EXPERIMENTAL CONDITIONS

		Configurations		
		Hangar 6	In-Line	Butterfly
With Climb Corridor	Phase I	1	2	3
Without Climb Corridor	Phase II	4	5	6

6

The experimental conditions shown in Table II are as follows:

1. Hangar 6 (Equipment Configuration): Phase I (with climb corridor).

2. In-Line (Equipment Configuration): Phase I (with climb corridor).

3. Butterfly (Equipment Configuration): Phase I (with climb corridor).

4. Hangar 6 (Equipment Configuration): Phase II (without climb corridor).

5. In-Line (Equipment Configuration): Phase II (without climb corridor).

6. Butterfly (Equipment Configuration): Phase II (without climb corridor).

These six experimental conditions were simulated, using one traffic sample (discussed in detail earlier in this report). However, it should be pointed out that, due to logistic considerations, one sample was used throughout the evaluation and the controllers became rather proficient by the end of the simulation. An attempt was made to compensate for this situation by changing the identities of the aircraft during the evaluation, and a slight improvement was noted.

For the purpose of a statistical analysis, these six conditions were studied using a minimum of six runs for each condition. In this experiment, the six runs for each condition were derived by having three crews of controllers work twice under each condition. This resulted in a total of 36 one-hour test runs, with each of the three crews of controllers doing 12 one-hour test runs. The three crews or teams were not independent, nor were they different controllers each time. Instead, the same controllers were rotated through different positions of operation under each team setup at each airport. This rotational arrangement was made in order to establish the three teams, as it was not possible to obtain any additional controllers to be used as independent subjects.

The complete experimental design is shown in Table III.

Another compromise had to be made in the running of this experimental design. In order to eliminate, or at least minimize, the learning effect in the experiment, it is standard practice to run the experimental conditions in random order. However, in this particular case, the equipment configurations were too large and complicated to make quick changes between them. Since there was a limited time allotted for the dynamic simulation, the only way to proceed was to run each configuration in its entirety and then go on to the next configuration. They were run in the following order:

(1) Hangar 6, (2) In-Line, and (3) Butterfly.

This learning effect seems to be reflected in the data and will be discussed later in the experimental results. The runs under each configuration were performed in random order, and practice runs were made before the start of the data runs to acquaint the controller teams with the control procedures used with the different configurations.

TABLE III

RUN SCHEDULE

Team		Configuration 1		Configuration 2		Configuration 3	
		Phase I	Phase II	Phase I	Phase II	Phase I	Phase II
1	R_1	6	5	18	17	30	29
	R_2	9	12	21	24	33	36
2	R_1	1	7	13	19	25	31
	R_2	4	8	16	20	28	32
3	R_1	2	3	14	15	26	27
	R_2	10	11	22	23	34	35

Configuration 1 - Hangar 6
Configuration 2 - In-Line
Configuration 3 - Butterfly

Phase I - With Climb Corridor
Phase II - Without Climb Corridor
R_1 and R_2 - Replications

All subjects were briefed on the purpose of the tests and the definition of the experimental conditions before the experiment started. Insofar as possible, the subjects were isolated from the mechanics and details of the simulation, so as to create a realistic situation.

System Performance Measures

The following measures were taken during the experiment, and are defined as shown:

1. Radar Vectors: Any change of heading given by a controller for conflict avoidance, guidance, or for the spacing of aircraft for proper arrival interval.

2. Altitude Changes: Any change of altitude, given by a controller, which deviated from the original cruising altitude.

3. Number of Delays at Feeder Fix: Number of times aircraft held at a feeder fix, as directed by a controller.

4. Duration of Delay at Feeder Fix: Length or time an aircraft was held at a feeder fix.

5. Number of Communications Contacts: Number of times the push-to-talk button was depressed by the controller during the hour run.

6. Duration of Communications: Length of time the push-to-talk button was depressed by the controller during the hour run.

7. Arrival Rate: Total number of aircraft arriving at each of the three airports in the terminal area during the one-hour run. Only those aircraft that had passed over the outer marker by the end of the problem run were counted as arrivals.

8. Arrival Interval: Interval of time between successive arrivals.

9. Vector Delay: Difference between the actual time in system from holding fix to outer marker and the theoretical time between the same points. The theoretical time is the optimum no-traffic time determined from prior testing.

10. Departure Rate: Total number of aircraft departing from each of the three airports in the terminal area during the one-hour run.

11. Departure Interval: Interval of time between successive departures.

12. Speed Change: Any change of speed, given by the controller, which deviated from the normal speed.

13. Center Arrival Delay: Difference between the time the pilot is ready to go and the actual start time in the system.

Summary and Submeasures

Several of the measures that were recorded were broken into submeasures or combined into summary measures before analysis:

1. Radar Vectors: Analyzed as (a) average number per run, and (b) average number per run per aircraft.

2. Altitude Changes: Analyzed as (a) average number per run, and (b) average number per run per aircraft.

3. Center Arrival Delays: Analyzed as (a) average number per run, (b) average duration per run, and (c) average duration per run per aircraft.

4. Feeder Fix Delays: Analyzed as (a) average number per run, (b) average duration per run, and (c) average duration per run per aircraft.

5. Arrivals: Analyzed as (a) average number per run per airport, and (b) average arrival interval per run per airport.

6. Vector Delays: Analyzed as average duration per run.

7. Speed Changes: Analyzed as average number per run.

8. Communications: Analyzed as (a) average number of contacts per run, and (b) average duration per run.

Run Score Development

Further study of the data was needed in order to make the analyses. Although the evaluation was conducted on a systematic basis, it is apparent that, in the case of Washington, the system is made up of three airport complexes. Since it was entirely possible that control problems at any one of the airports could be masked out by merely evaluating the overall system, it was decided to consider the data on an airport basis and show what was happening within the system. Therefore, comparison between systems for analytical purposes was based on the airport, phase, and controller team.

After considering the data for each airport and taking a mean of the like cells under each experimental condition, the experimental design was analyzed as shown in Table IV.

TABLE IV

DESIGN ANALYSIS

		Configuration	
		Phase I Runs	Phase II Runs
Dulles	Team 1	2	2
	Team 2	2	2
	Team 3	2	2
Andrews	Team 1	2	2
	Team 2	2	2
	Team 3	2	2
DCA	Team 1	2	2
	Team 2	2	2
	Team 3	2	2
		Total of Average Pairs 18	

As stated before, the controller teams rotated through different positions of operation at each airport. The arrivals and the departures were considered separate measures and analyzed as such, as it was felt this would give a better presentation of the happenings inside the overall system configurations.

Explanation of Results

After consideration of various methods of analysis, two methods were chosen which could meet the necessary assumptions for analysis. These were the Wilcoxon matched-pairs, signed-ranks test and the Colin White signed-ranks test. These methods are very similar, the principal difference being that the Colin White test has lower limits of usability. In other words, it needs fewer data points to make the analysis. Both of these tests consider the relative magnitude as well as the direction of the difference. Even though the tests give more weight to a pair showing a large difference between two conditions than to a pair showing a small difference, the direction of the difference is the biggest factor in determining whether there is a significant difference or not. Therefore, it must be realized that, when two systems are indicated to be significantly different, it is not always a large difference between the systems but that the difference is consistent in one direction.

In presenting the results of this analysis, the .01 level of significance was considered to be the point between significance and nonsignificance for the variables with respect to any particular measure. The .01 level of significance means that to state that a difference exists between the variables, such statement would be correct 99 per cent of the time. This rather high significance level was chosen to compensate for any irregularities in the data or the procedures which might have occurred during the running of the simulation.

The results of these analyses are shown in Tables V, VI, VII, and VIII. The actual measures used to evaluate the variables are listed in the left-hand column. The overall means, or averages, are listed in the center under the particular measure being evaluated.

Briefly, the results of the analysis show that, with respect to the measures used for evaluation, the equipment configurations could be ranked in the following order: (1) Butterfly, (2) In-Line, and (3) Hangar 6. However, there appeared to be very little difference between any of the configurations, especially between the In-Line and the Butterfly. Since this is the case, the learning factor that emerges when the configurations cannot be randomized during the running of the experimental design becomes a possible error factor that would tend to favor the configurations in the order tested.

Insofar as the phases were concerned, neither showed any particular advantage. It didn't seem to matter if the climb corridor was there or not. In summary, the controllers' function, as an overall group, remained relatively similar throughout the three equipment configurations. Even though some of the individual controllers' areas of jurisdiction varied slightly between the three equipment configurations, the end result was that the sum total of all the controllers' areas of jurisdiction remained equal. Therefore, due to the fact that there were no outstanding differences between the equipment configurations or phases, the number of measures showing significant differences was relatively small.

TABLE V

SUMMARY OF SIGNIFICANT DIFFERENCES BETWEEN CONFIGURATIONS FOR ARRIVALS

Measures	Configurations			Significance
	Hangar 6	In-Line	Butterfly	
Average number of radar vectors per run.	131.4	122.3		.01 Level
		122.3	109.8	NSD*
	131.4		109.8	.01 Level
Average number of radar vectors per aircraft per run.	4.40	4.00		.01 Level
		4.00	3.63	NSD
	4.40		3.63	.01 Level
Average number of altitude changes per run.	47.2	44.3		.01 Level
		44.3	45.4	NSD
	47.2		45.4	NSD
Average number of altitude changes per aircraft per run.	1.58	1.44		.01 Level
		1.44	1.47	NSD
	1.58		1.47	.01 Level
Average number of center delays per run.	2.02	1.47		NSD
		1.47	1.36	NSD
	2.02		1.36	NSD
Average duration of center delays per run (minutes).	4.04	2.51		NSD
		2.51	2.19	NSD
	4.04		2.19	NSD
Average duration of center delay per aircraft delayed per run (minutes).	1.28	.79		NSD
		.79	.90	NSD
	1.28		.90	NSD

*NSD: No significant difference

TABLE V (Continued)

SUMMARY OF SIGNIFICANT DIFFERENCES
BETWEEN CONFIGURATIONS FOR ARRIVALS

Measures	Configurations: Hangar 6	In-Line	Butterfly	Significance
Average number of delays at feeder fix per run.	1.30	1.11		NSD
		1.11	1.47	NSD
	1.30		1.47	NSD
Average duration of delays at feeder fix per run (minutes).	2.68	2.08		NSD
		2.08	2.67	NSD
	2.68		2.67	NSD
Average duration of delay at feeder fix, per aircraft delayed per run (minutes).	1.07	1.20		NSD
		1.20	.97	NSD
	1.07		.97	NSD
Average number of arrivals per airport per run.	30.1	30.9		NSD
		30.9	31.1	NSD
	30.1		31.1	.01 Level
Average arrival interval per airport per run.	1.99	1.94		NSD
		1.94	1.92	NSD
	1.99		1.92	.01 Level
Average vector delay per run (minutes).	85.66	72.43		.01 Level
		72.43	71.04	NSD
	85.66		71.04	NSD
Average number of speed changes per run.	28.4	25.8		NSD
		25.8	27.1	NSD
	28.4		27.1	NSD

TABLE V (Continued)

SUMMARY OF SIGNIFICANT DIFFERENCES BETWEEN CONFIGURATIONS FOR ARRIVALS

Measures	Configurations: Hangar 6	In-Line	Butterfly	Significance
Communications: Average number of communication contacts per position per run.	139.7	139.6		NSD
		139.6	126.2	.01 Level
	139.7		126.2	.01 Level
Communications: Average duration of communications per position per run (sec.)	511.7	480.6		NSD
		480.6	427.3	.01 Level
	511.7		427.3	.01 Level
Controller Opinion Overall Average System Rating	2.27	2.68		.01 Level
		2.68	1.90	.01 Level
	2.27		1.90	.01 Level

TABLE VI

SUMMARY OF SIGNIFICANT DIFFERENCES BETWEEN CONFIGURATIONS FOR DEPARTURES

Measures	Configurations			Significance
	Hangar 6	In-Line	Butterfly	
Average number of radar vectors per run.	35.4	32.4		NSD
		32.4	34.1	NSD
	35.4		34.1	NSD
Average number of radar vectors per aircraft per run.	1.35	1.21		NSD
		1.21	1.31	NSD
	1.35		1.31	NSD
Average number of altitude changes per run.	10.3	11.9		NSD
		11.9	11.9	NSD
	10.3		11.9	NSD
Average number of altitude changes per aircraft per run.	.39	.45		NSD
		.45	.45	NSD
	.39		.45	NSD
Average number of departures per airport per run.	26.2	26.2		NSD
		26.2	26.3	NSD
	26.2		26.3	NSD

TABLE VII

SUMMARY OF SIGNIFICANT DIFFERENCES
BETWEEN PHASES FOR ARRIVALS

Measures	Phase I	Phase II	Significance
Average number of radar vectors per run:			
Hangar 6	130.3	132.6	NSD
In-Line	122.1	122.4	NSD
Butterfly	115.4	104.1	NSD
Average number of radar vectors per aircraft per run:			
Hangar 6	4.35	4.44	NSD
In-Line	4.02	3.93	NSD
Butterfly	3.70	3.55	NSD
Average number of altitude changes per run:			
Hangar 6	46.4	48.0	NSD
In-Line	44.2	44.6	NSD
Butterfly	45.6	45.3	NSD
Average number of altitude changes per aircraft per run:			
Hangar 6	1.55	1.60	.02 Level
In-Line	1.45	1.43	NSD
Butterfly	1.46	1.47	NSD
Average number of center delays per run:			
Hangar 6	1.94	2.16	NSD
In-Line	1.17	1.78	NSD
Butterfly	1.28	1.44	NSD

TABLE VII (Continued)

SUMMARY OF SIGNIFICANT DIFFERENCES BETWEEN PHASES FOR ARRIVALS

Measures	Phase I	Phase II	Significance
Average duration of center delays per run (minutes):			
Hangar 6	4.58	3.50	NSD
In-Line	2.27	2.63	NSD
Butterfly	1.85	2.52	NSD
Average duration of center delays per aircraft delayed per run:			
Hangar 6	1.22	1.33	NSD
In-Line	.92	.64	NSD
Butterfly	.75	1.04	NSD
Average number of delays at feeder fix per run:			
Hangar 6	1.42	1.18	NSD
In-Line	1.22	1.00	NSD
Butterfly	1.39	1.56	NSD
Average duration of delays at feeder fix per run (minutes):			
Hangar 6	2.65	2.60	NSD
In-Line	2.36	1.79	NSD
Butterfly	2.78	2.56	NSD
Average duration of delay at feeder fix per aircraft delayed per run (minutes):			
Hangar 6	.66	1.48	NSD
In-Line	1.44	.95	NSD
Butterfly	.82	1.12	NSD

TABLE VII (Continued)

SUMMARY OF SIGNIFICANT DIFFERENCES
BETWEEN PHASES FOR ARRIVALS

Measures	Phase I	Phase II	Significance
Controller Opinion Overall Average System Rating:			
Hangar 6	2.30	2.24	NSD
In-Line	2.68	2.69	NSD
Butterfly	1.92	1.88	NSD
Average number of arrivals per airport per run:			
Hangar 6	30.2	30.0	NSD
In-Line	30.5	31.3	NSD
Butterfly	31.2	31.0	NSD
Average arrival interval per airport per run:			
Hangar 6	1.98	2.00	NSD
In-Line	1.96	1.91	NSD
Butterfly	1.92	1.93	NSD
Average vector delay per run (minutes):			
Hangar 6	79.4	92.9	NSD
In-Line	74.6	70.2	NSD
Butterfly	72.1	69.9	NSD
Average number of speed changes per run:			
Hangar 6	28.5	28.4	NSD
In-Line	26.8	28.3	NSD
Butterfly	29.2	25.1	.01 Level

TABLE VII (Continued)

SUMMARY OF SIGNIFICANT DIFFERENCES
BETWEEN PHASES FOR ARRIVALS

Measures	Phase I	Phase II	Significance
Average number of communication contacts per position per run:			
Hangar 6	141.1	138.3	NSD
In-Line	138.6	140.6	NSD
Butterfly	129.4	211.9	NSD
Average duration of communication per position per run (seconds):			
Hangar 6	511.1	512.3	NSD
In-Line	477.7	483.6	NSD
Butterfly	436.1	418.6	NSD

TABLE VIII

SUMMARY OF SIGNIFICANT DIFFERENCES BETWEEN PHASES FOR DEPARTURES

Measures	Phase I	Phase II	Significance
Total number of radar vectors per run:			
Hangar 6	35.0	35.9	NSD
In-Line	33.3	31.5	NSD
Butterfly	31.7	36.6	NSD
Average number of radar vectors per aircraft per run:			
Hangar 6	1.35	1.36	NSD
In-Line	1.20	1.22	NSD
Butterfly	1.22	1.40	NSD
Average number of altitude changes per run:			
Hangar 6	10.2	10.4	NSD
In-Line	10.7	13.0	NSD
Butterfly	11.7	12.0	NSD
Average number of altitude changes per aircraft per run:			
Hangar 6	.39	.39	NSD
In-Line	.40	.49	NSD
Butterfly	.44	.45	NSD
Average number of departures per airport per run:			
Hangar 6	26.1	26.4	NSD
In-Line	26.2	26.2	NSD
Butterfly	26.2	25.3	NSD

Graphical Presentation of Results

The analytical results of some of the more important measures are presented in Figs. 36 through 49. Some graphs are plotted, using the same numerical values that were used in the analysis. Therefore, they show the differences that occurred in the control of the aircraft traversing the system into each of the airports. More important, the graphs show the differences in the equipment configurations at each airport and at all airports. It can readily be seen that those measures, in which the analysis showed significant configuration differences, show a consistently higher or lower trend, depending on the direction of the difference. Preceding the graphs are statements giving possible operational explanations for the differences indicated between the individual airport operation.

Radar Vectors - Arrivals: The number of radar vectors in Fig. 36 shows Andrews with the least amount. This probably was caused by the jet arrivals which were not vectored to the final approach course, but only cleared for penetrations.

Radar Vector Delay: The amount of radar vector delay in Fig. 37 shows that Andrews arrival traffic, on the whole, received the least. This could be because jets were held in the holding pattern until a penetration could be made without being subjected to vectors to establish separation. One possible explanation for Washington having more than Dulles could be that Washington has four inbound routes as compared to Dulles two, which might require vectoring on the part of Washington to establish a landing sequence.

Altitude Changes - Arrivals: Altitude changes in Fig. 38 show that the Andrews traffic had the fewest. This could be attributed to jet arrivals making penetrations and not being restricted to specific altitudes on descent. Altitude changes for arrival aircraft at Washington and Dulles were comparable; however, they differed greatly from Andrews.

Center Arrival Delay - Number: The greatest number of Center delays (Fig. 39) was absorbed by Dulles arrival traffic, as opposed to Andrews arrivals which received the least. A possible explanation for the Dulles figures might be attributable to the Charles Town clearance limit's proximity to the ILS final approach course. This fact caused the center controller to delay some arrivals in order to establish a reasonable

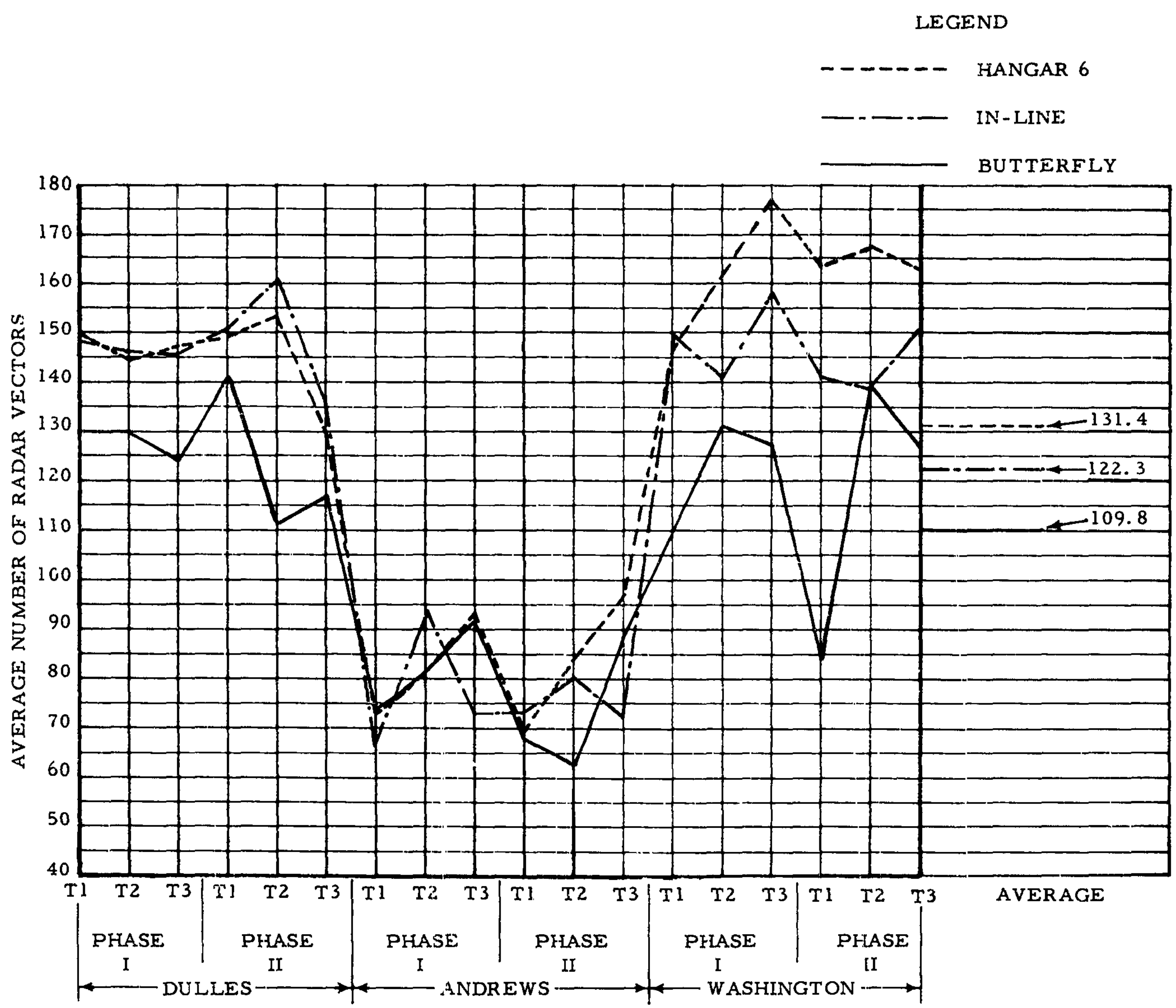


FIG. 36 AVERAGE NUMBER OF RADAR VECTORS PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

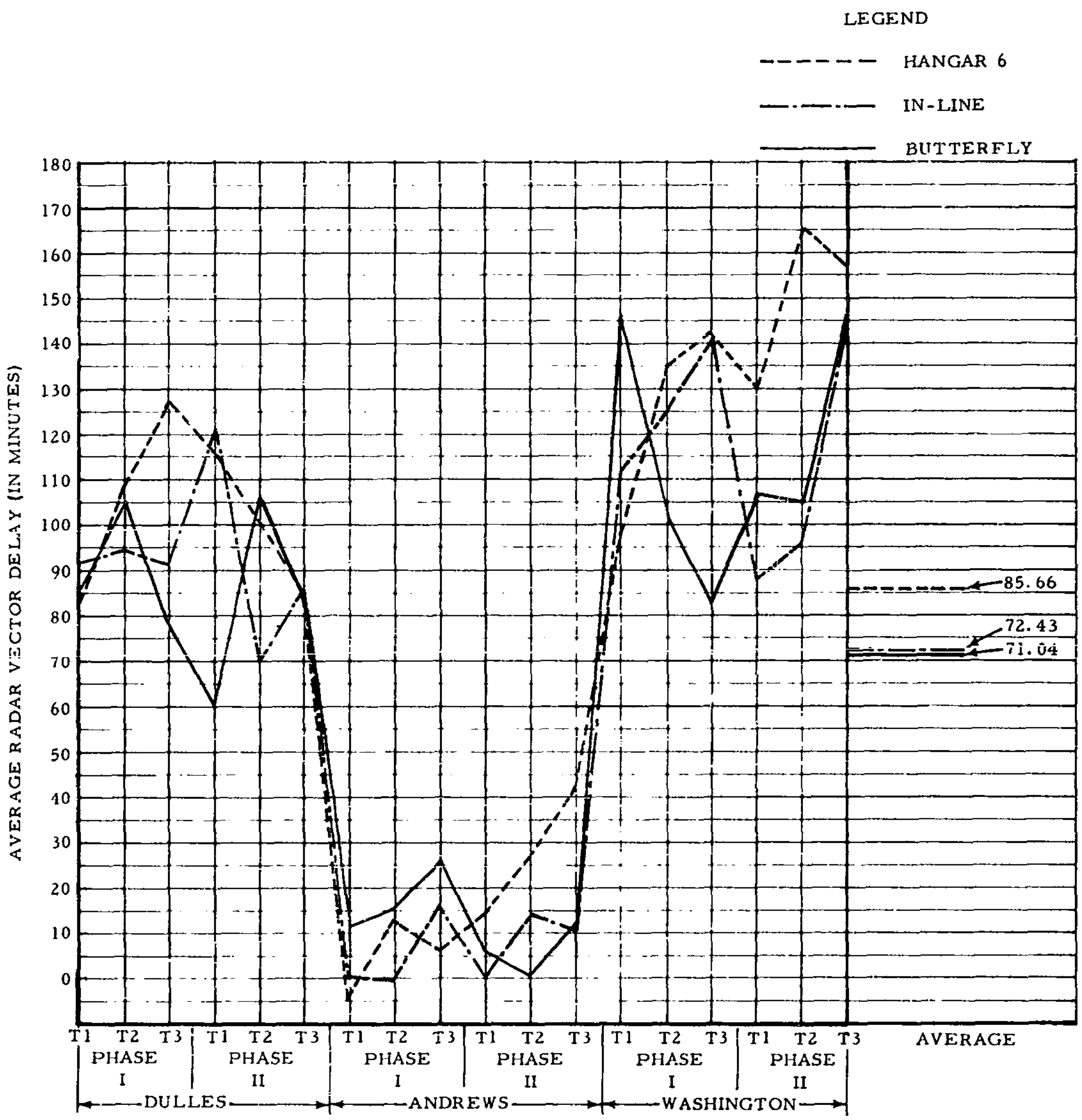


FIG. 37 AVERAGE RADAR VECTOR DELAY FOR ARRIVALS IN MINUTES PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

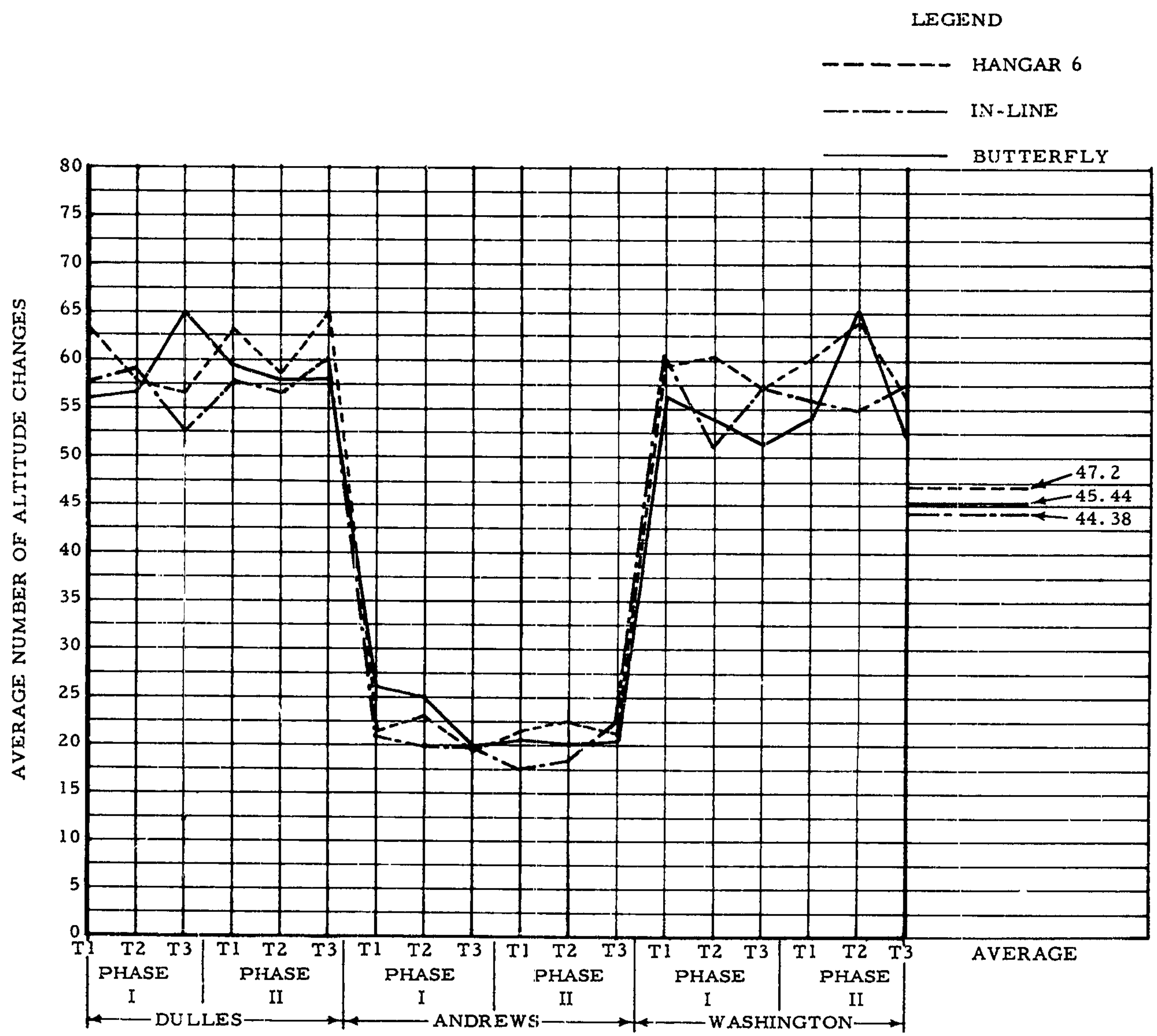


FIG. 38 AVERAGE NUMBER OF ALTITUDE CHANGES FOR ARRIVALS PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

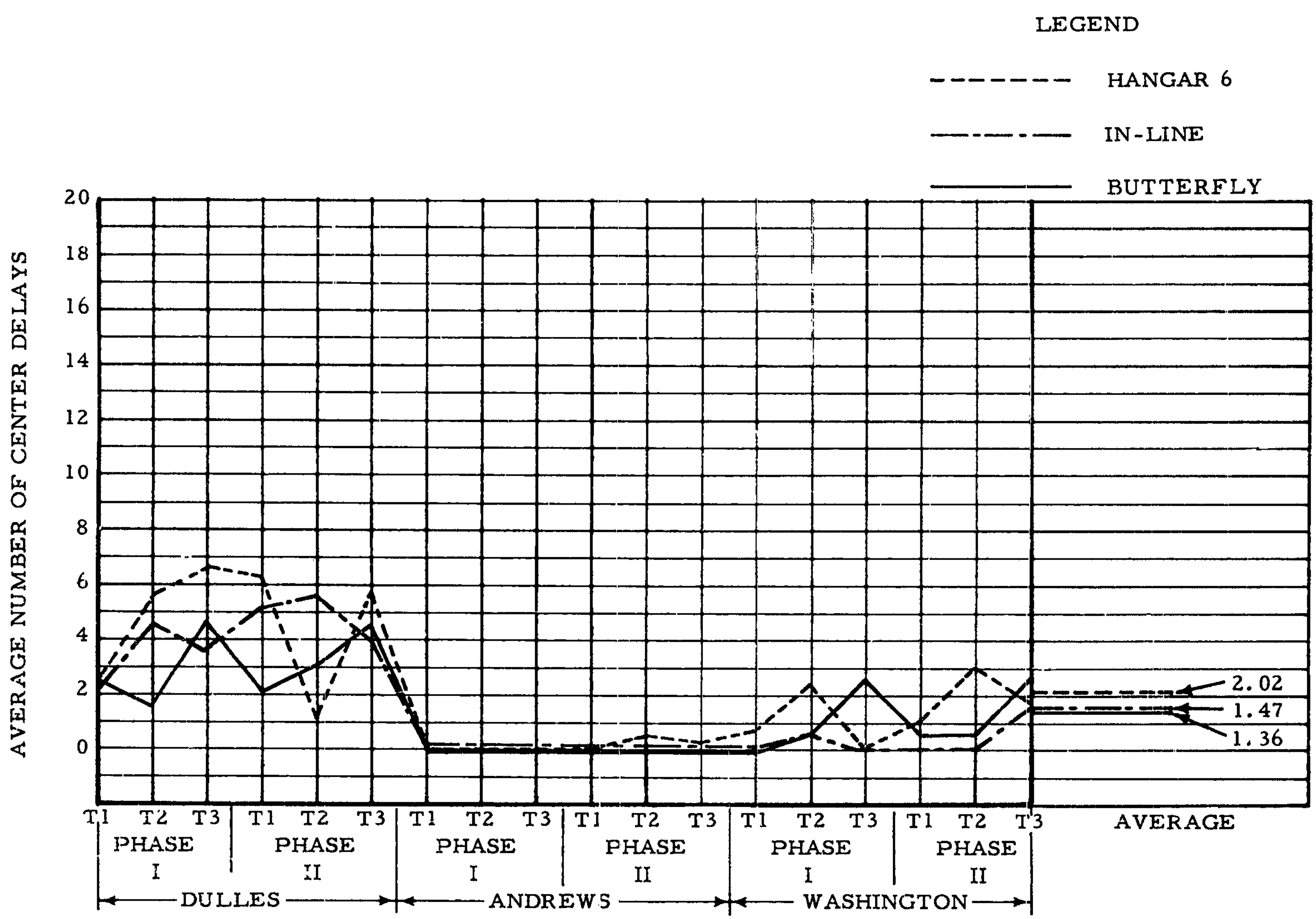


FIG. 39 AVERAGE NUMBER OF CENTER DELAYS FOR ARRIVALS PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

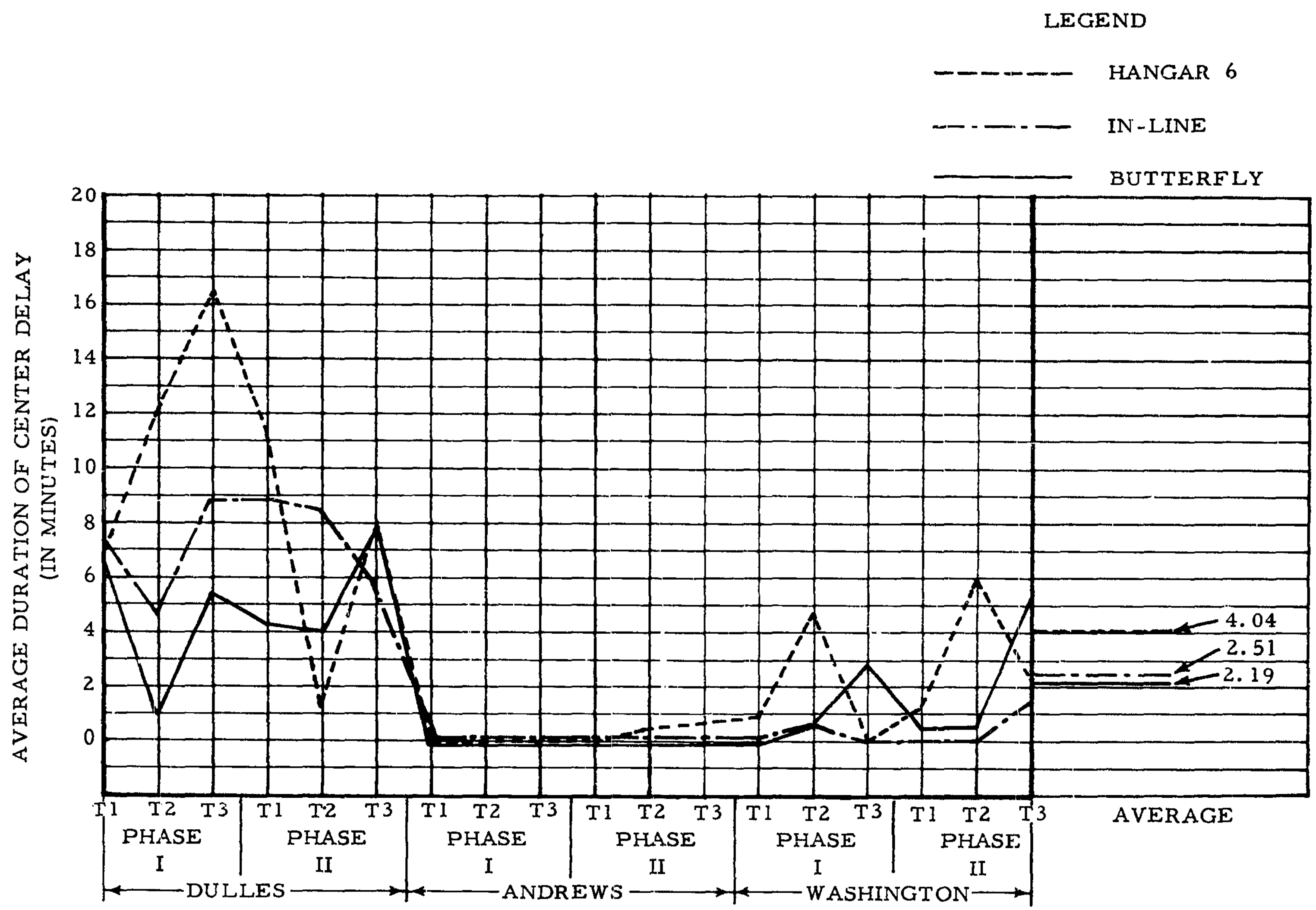


FIG. 40 AVERAGE DURATION OF CENTER DELAYS FOR ARRIVALS IN MINUTES PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

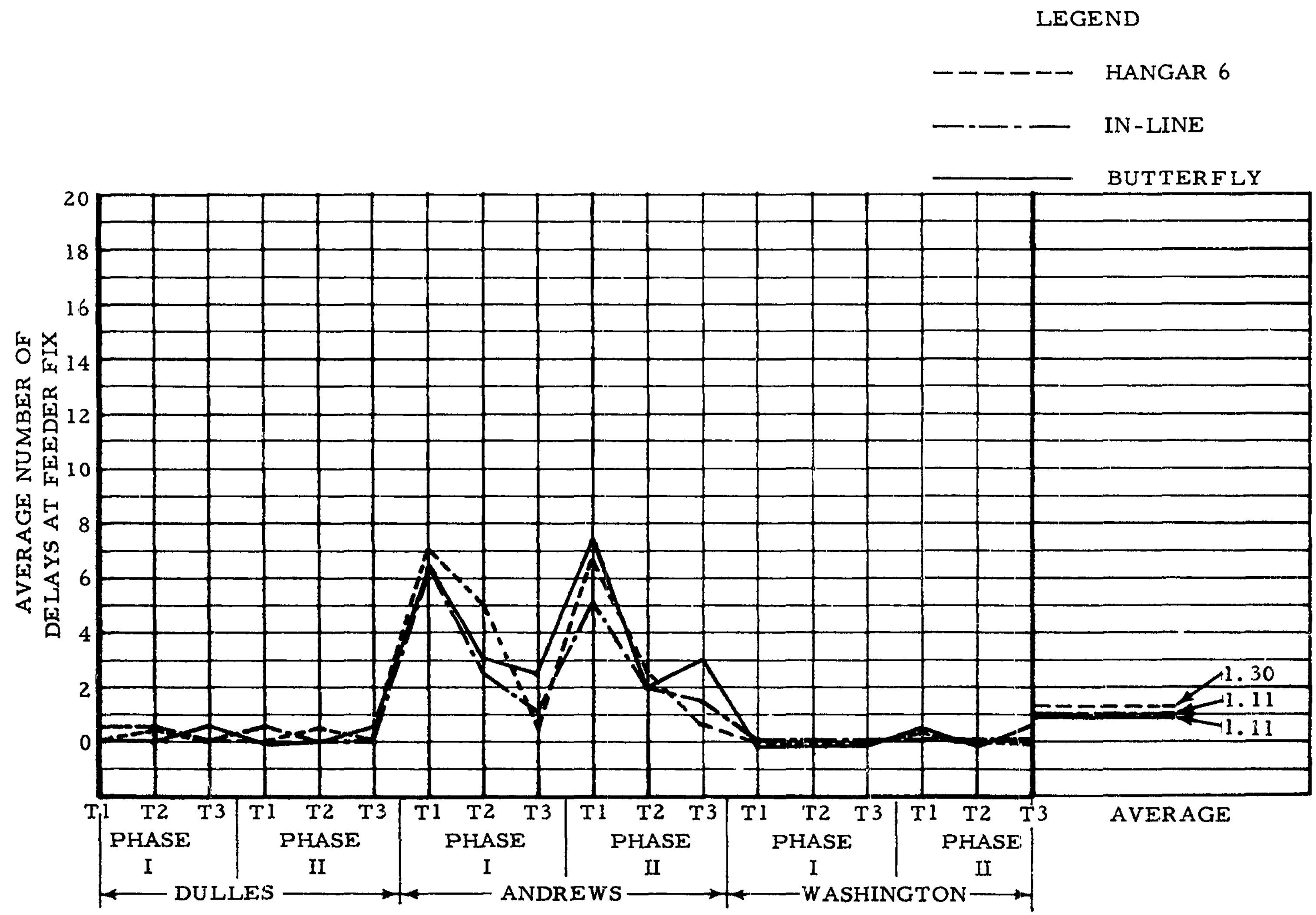


FIG. 41 AVERAGE NUMBER OF DELAYS AT FEEDER FIX FOR ARRIVALS PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

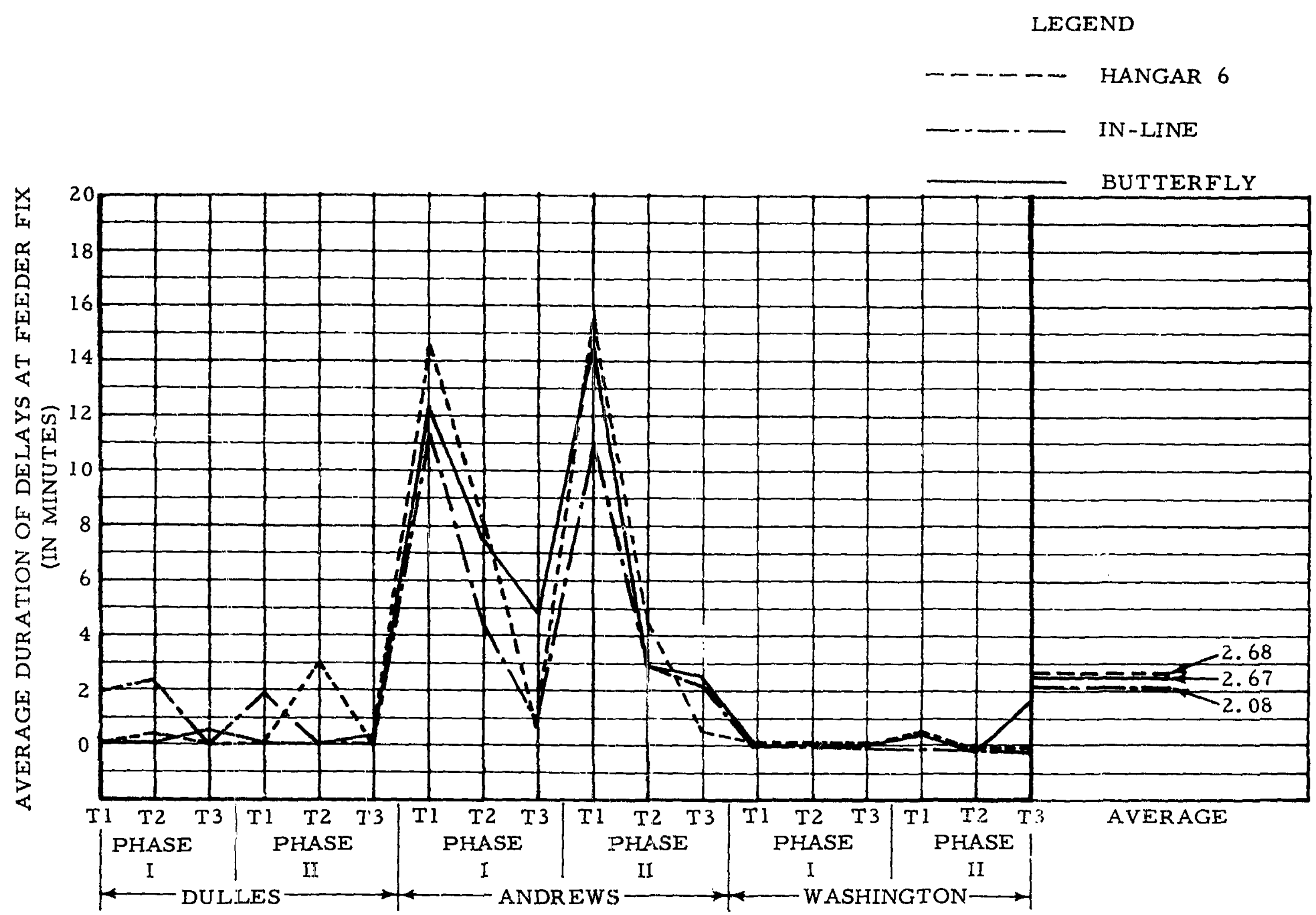


FIG. 42 AVERAGE DURATION OF DELAYS AT FEEDER FIX FOR ARRIVALS PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

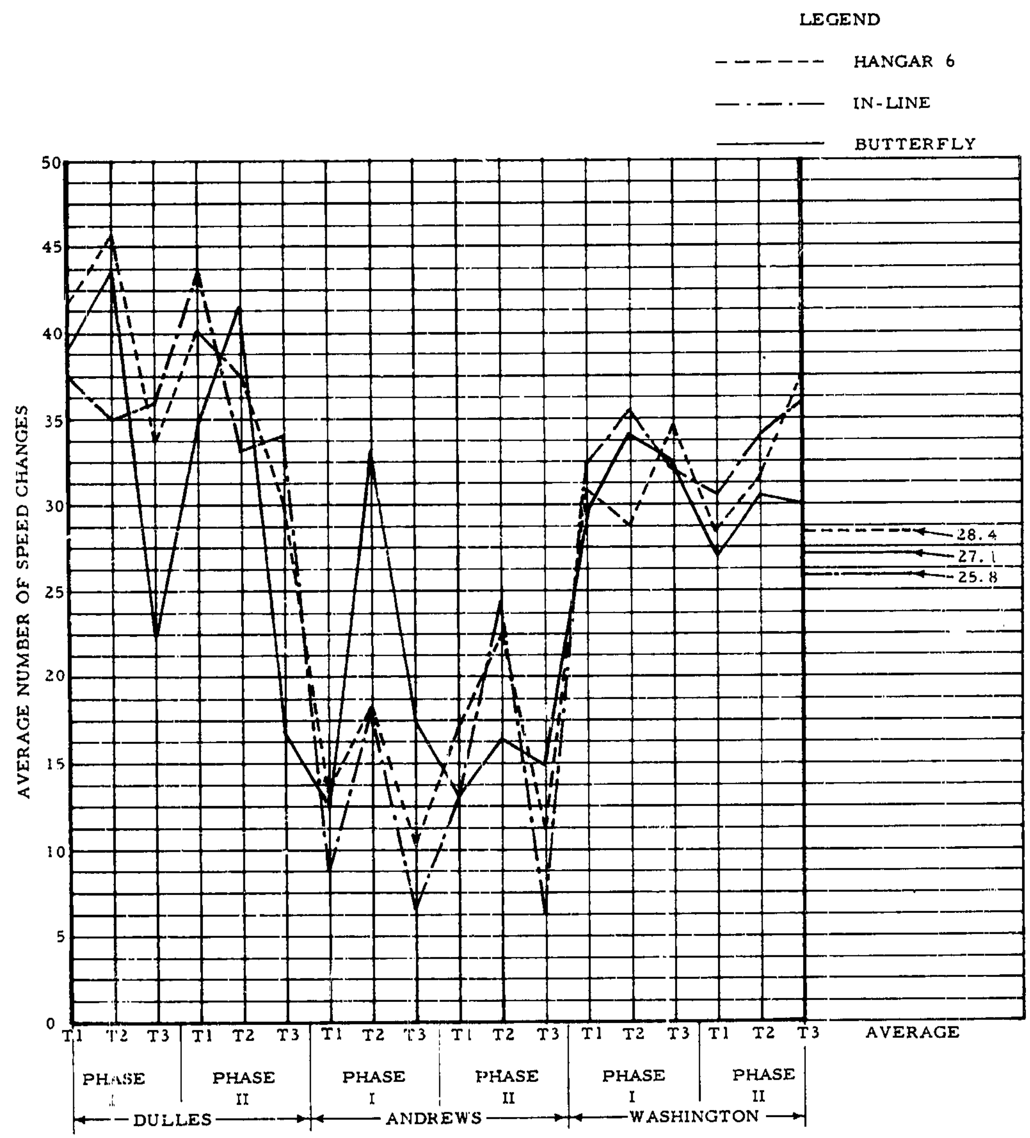


FIG. 43 AVERAGE NUMBER OF SPEED CHANGES FOR ARRIVALS PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

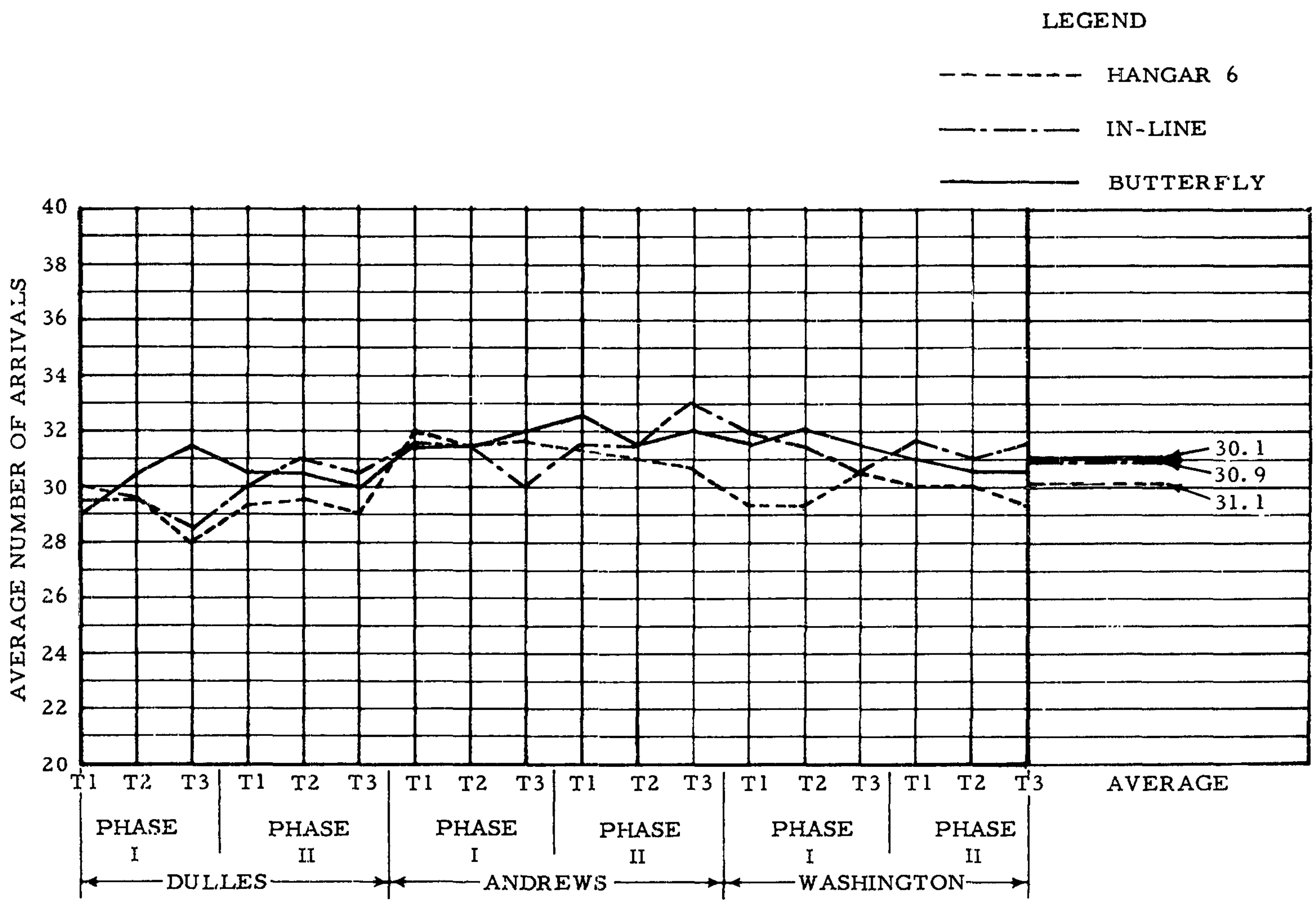


FIG. 44 AVERAGE NUMBER OF ARRIVALS PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

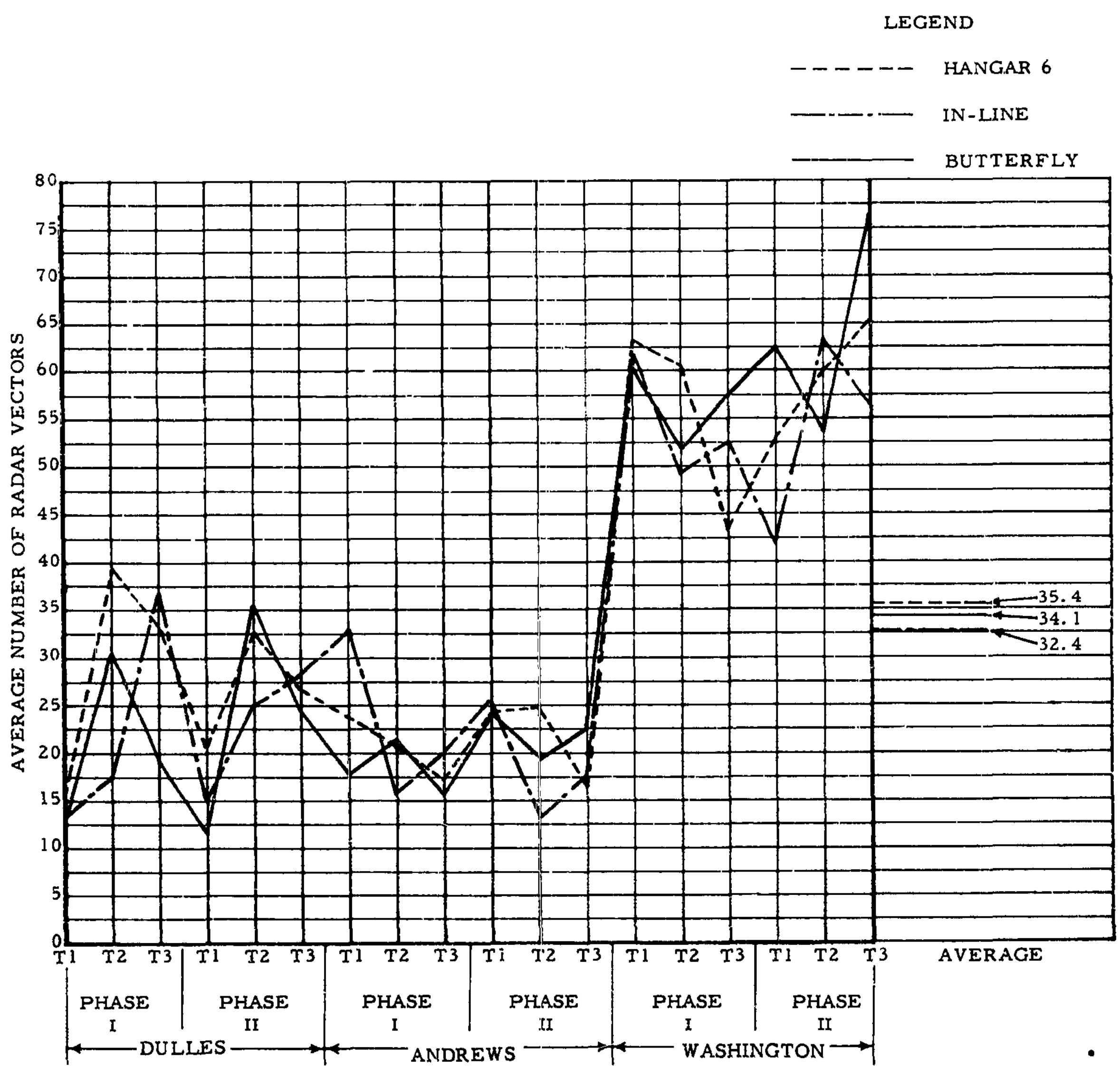


FIG. 45 AVERAGE NUMBER OF RADAR VECTORS FOR DEPARTURES PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

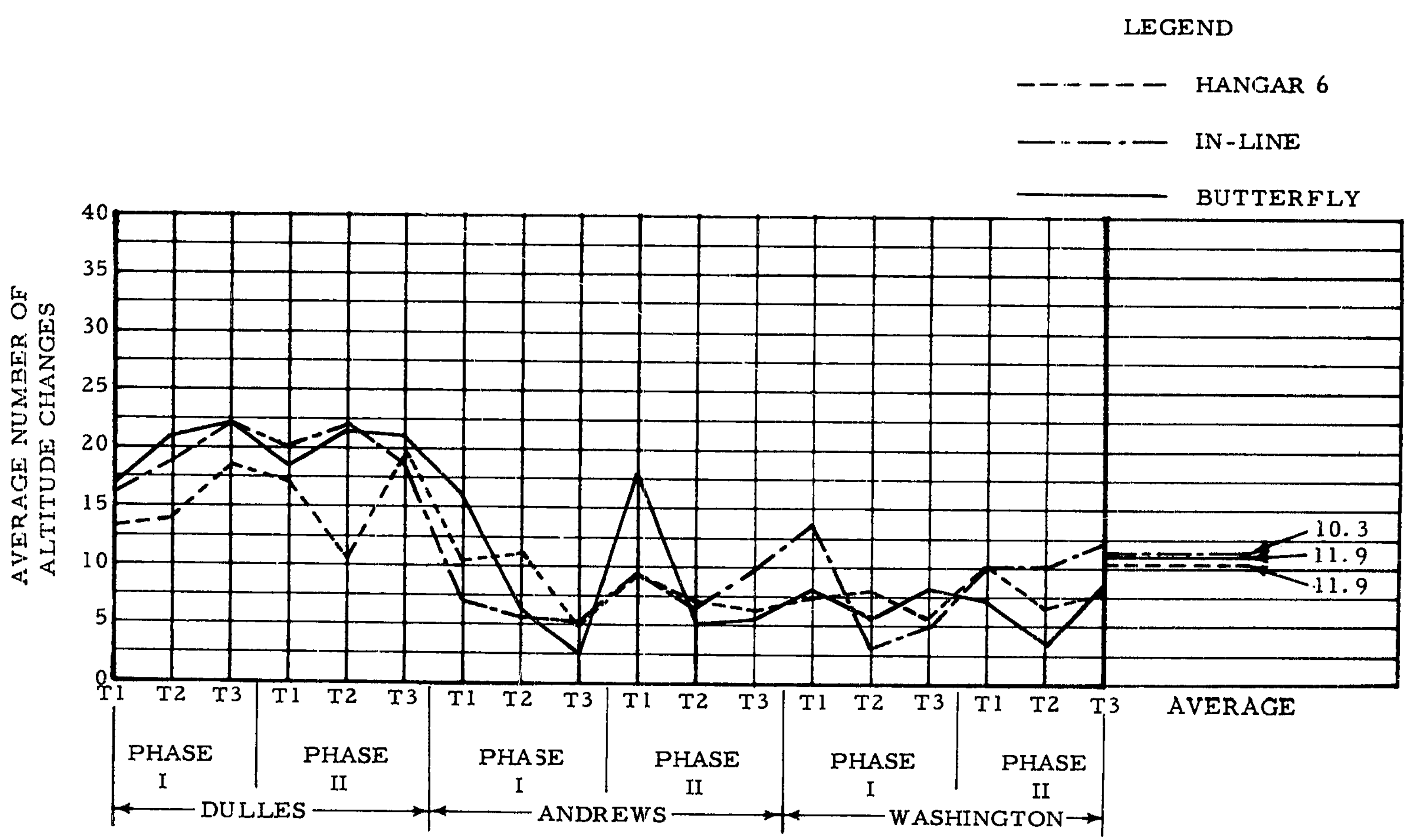


FIG. 46 AVERAGE NUMBER OF ALTITUDE CHANGES FOR DEPARTURES PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

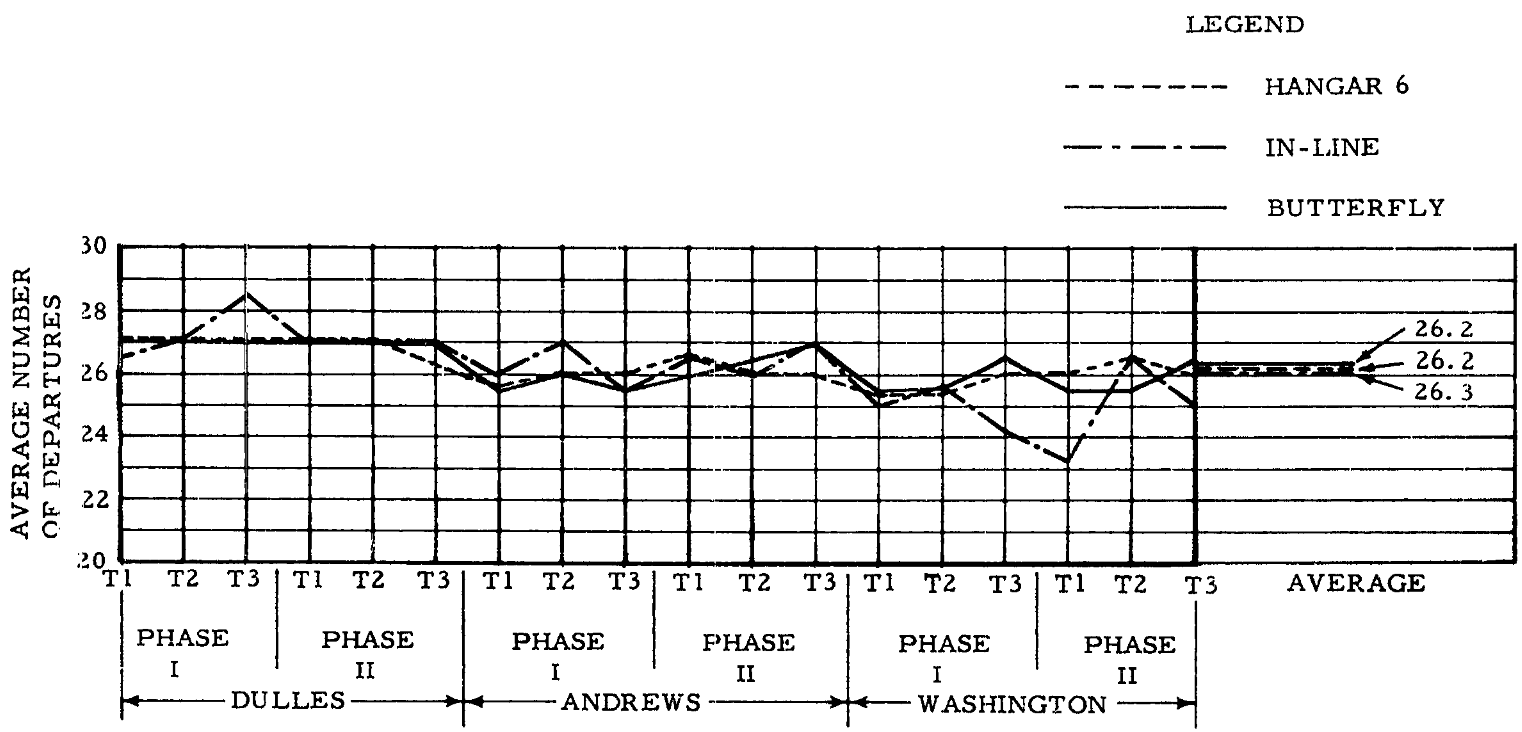


FIG. 47 AVERAGE NUMBER OF DEPARTURES PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

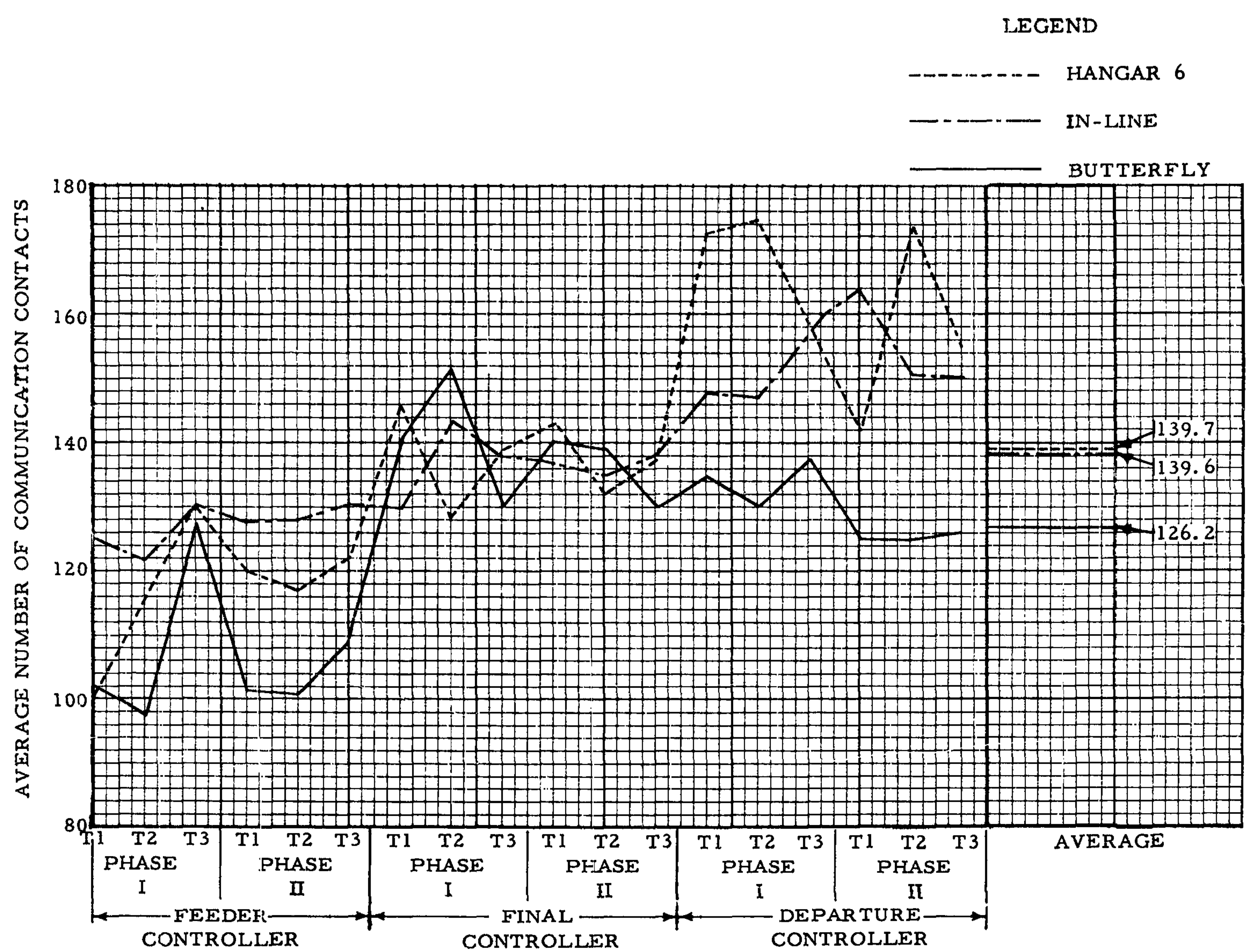


FIG. 48 AVERAGE NUMBER OF COMMUNICATION CONTACTS PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

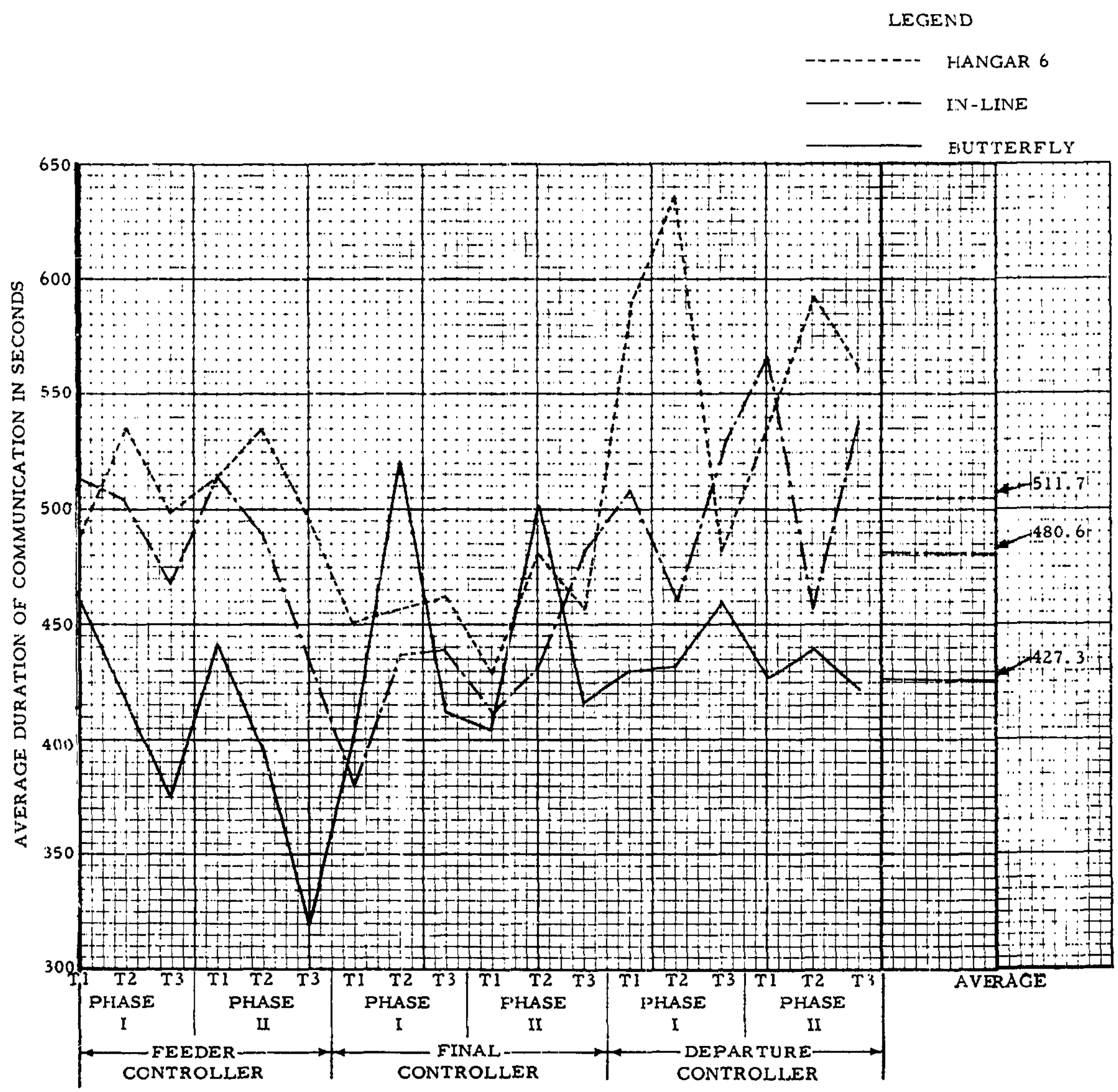


FIG. 49 AVERAGE DURATION OF COMMUNICATION PER RUN BY TEAM, PHASE, AIRPORT AND CONFIGURATION

sequence before handing off to the transition controller, who had little time or space in which to make an adjustment to this office.

Center Arrival Delay - Duration Minutes: Center delay in minutes (Fig. 40) shows that Dulles had a maximum delay under the Hangar 6 configuration of 16.6 minutes. Considering that the number of aircraft delayed was 6.5 (Fig. 39), the average center delay for each aircraft in this case was less than 3 minutes.

Holding Pattern Delay - Number: Holding pattern delay in Fig. 41 shows that the majority of delays were encountered by arrival traffic at Andrews. This was because the majority were jets which during the simulation, entered the problem in the holding pattern and held until they could start a penetration to Andrews.

Holding Pattern Delay - Minutes: Holding pattern delay in Fig. 42 shows that the delay in minutes is small per aircraft when compared with the number that were held (Fig. 41). In considering the first peak at Andrews, Team 1, the number of minutes' delay here under the Hangar 6 configuration is 14.76. Dividing this by 7 aircraft delayed (Fig. 41), same team and configuration, the average delay per aircraft in the holding pattern is about 2 minutes.

Number of Speed Changes: Speed changes in Fig. 43 show that Andrews traffic received the least number. This was because jets, which comprised the majority of traffic, made penetrations, and no speed changes were issued by the controllers to these aircraft.

Number of Arrivals: The number of arrivals (Fig. 44), by airports, remained relatively similar and centered around 30.5 per hour.

Radar Vectors - Departures: Radar vectors in Fig. 45 show Washington with the highest number. This could be an indication that these departures required more vectoring before becoming established on course. One instance was traffic proceeding via V3 or V140, which was vectored to Woodbridge before proceeding on course, since Woodbridge is a VOR intersection..

Altitude Changes - Departures: The number of altitude changes for departures in Fig. 46 show that Dulles departure traffic received the highest number. This could be attributed to the fact that most of the departures routed out of Dulles had two restrictions. The proximity of the Herndon VOR to arrival traffic inbound to Washington and Andrews crossing at this point imposed the initial restriction. Washington and Andrews did not have this situation.

Number of Departures: The number of departures (Fig. 47) by airports was similar, with Dulles having the slightly highest rate. The difference between the averages of the three equipment configurations was extremely small, with the greatest difference being only 0.1.

Communications: The number and duration of communications are shown in Figs. 48 and 49. Communications, both contacts and duration, were compared in a different way from the rest of the measures. Since the recording of communications was based on the control positions, the comparison had to be made by positions. The positions then were grouped into feeder, final, and departure positions. The statistical analysis was made on the basis of this grouping.

The results of the analysis showed that the Butterfly configuration reflected significantly fewer communications than the other configurations. However, it must be remembered that the Butterfly configuration had two additional operating positions, which would tend to bring the average down.

Correlation of Controller Subjective Opinion with Objective Data

As was previously stated, two types of questionnaires were filled out by the controllers, the rating-scale type and the narrative type (Appendices IV and V, respectively).

It was decided to analyze the data from the rating-scale questionnaire in two ways: (1) an overall average of the data between systems and an analysis to determine whether, in the opinion of the controllers, there was any difference between the three equipment configurations, and (2) a correlation analysis between the questionnaire data and the experimental data. The results of the system mean analysis are summarized in Table IX.

The purpose of this study was to determine the relationship that existed between objective measures taken during the experimental runs and the controllers' subjective opinion concerning these measures. The average rating of controllers in a particular team was compared to the corresponding measures achieved by the same team and under the same system configuration.

The two-variable, linear-correlation, analysis technique was used to examine the relationship between the measures and corresponding controllers' opinions of same measures. A summary of coefficients of correlation (r) between the measures and controllers' ratings under different system configurations is given in Table IX.

TABLE IX

SYSTEM MEAN ANALYSIS

Measures	H-6	In-Line	Butterfly	Average (r) for Measure	Spread of Data Observations
Average speed changes	0.779	0.713	0.558	0.683	0 - 50
Average altitude changes	0.734	0.566	0.655	0.651	0 - 70
Average radar vectors	0.509	0.481	0.356	0.448	0 - 180
Average communication duration	-0.312	-0.043	0.436	0.027	0 - 650
Average (r) for system	0.428	0.429	0.501	0.453	

Following are the findings of the study:

1. Out of four measures discussed, the controllers' judgment was nearer to reality (r = 0.683) for the measure of average speed changes. Their judgment deviated more and more from reality in the remaining measures.

2. It appeared that controllers can judge more correctly for a smaller spread of observations than when the spread is larger, as the spread becomes larger, it may be difficult to discriminate between two measures on the judgment scale (1 to 7).

3. Where the spread was very large, as in the case of communication duration, the judgments by controllers seemed to be almost independent of the actual communication time.

4. For the same measure, the controllers were more or less consistent in their judgment across the three systems, Hangar 6, In-Line, and Butterfly. Only for communication duration did the results seem unrealistic. Except for the Butterfly system, the tendency was to rate reverse (coefficient of correlation was negative) of what the actual observations would suggest.

The meaning of coefficient of correlation (r) as used for this analysis may be interpreted as follows: (r) actually indicates the degree of association between two variables and their joint behavior. In this case, if the coefficient of correlation is one between any selected measure and the controllers' opinion for that measure, it can be said that the opinions of controllers and the actual measures are absolutely relevant. As the coefficient of correlation between the two decreases, the controllers are departing in (their) judgment from reality.

The following may be the important factors affecting the judgments of controllers:

1. Individual perception (personal factor and bias).

2. Length of questionnaire.

3. Wide spread of judgment (opinion) scale.

4. Wide range of measures.

5. Inadequate understanding of the questionnaire by controllers.

The results of this analysis are based on a rather small sample of measures and but one type of rating-scale questionnaire. However, it is planned to continue the correlation analysis with a broader base in future simulations to enable the evaluater to acquire some feeling for the accuracy of controller subjective opinion.

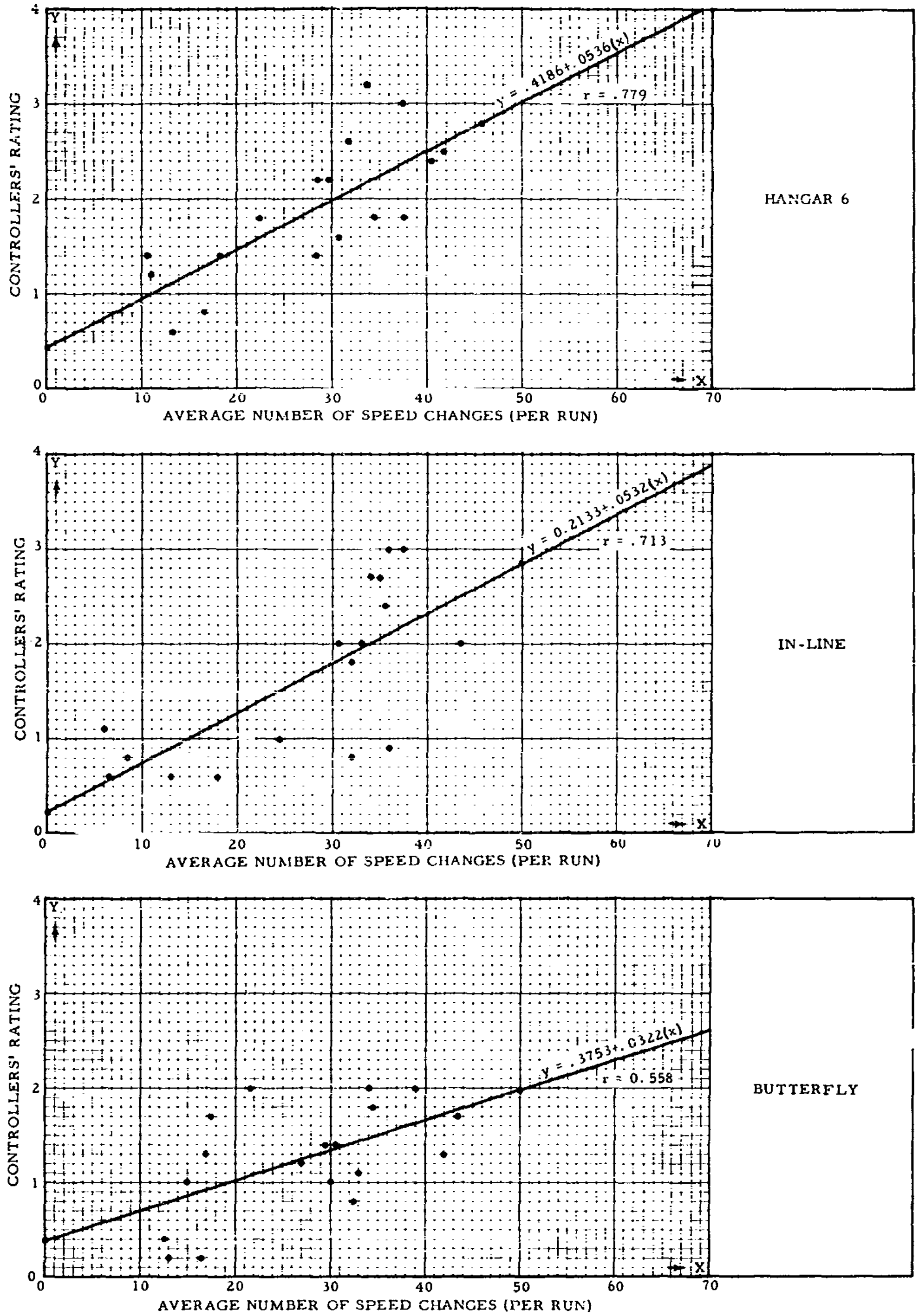


FIG. 50 COMPARISON OF SPEED CHANGE COEFFICIENTS OF CORRELATION BETWEEN CONFIGURATIONS

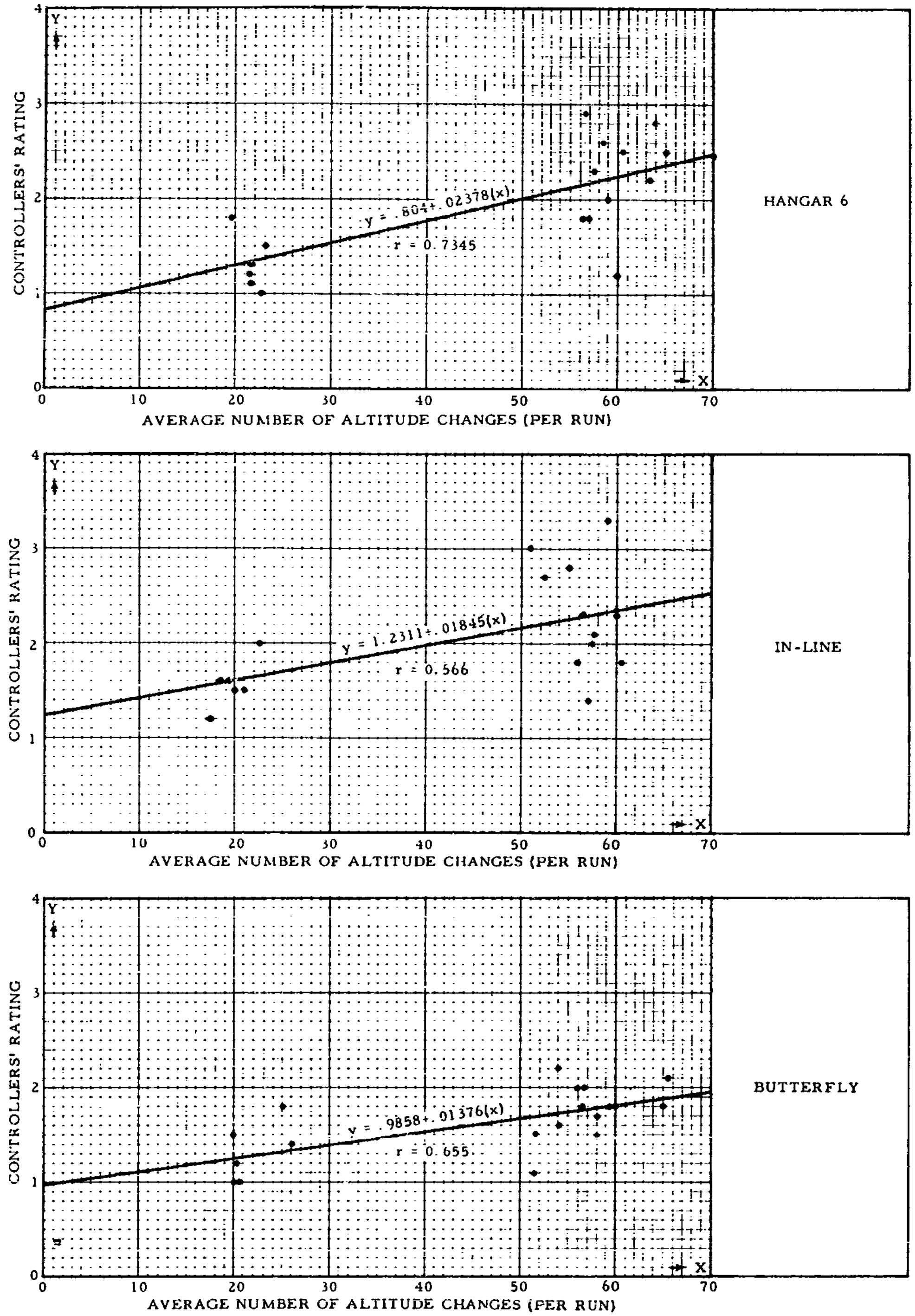


FIG. 51 COMPARISON OF ALTITUDE CHANGE COEFFICIENTS OF CORRELATION BETWEEN CONFIGURATIONS

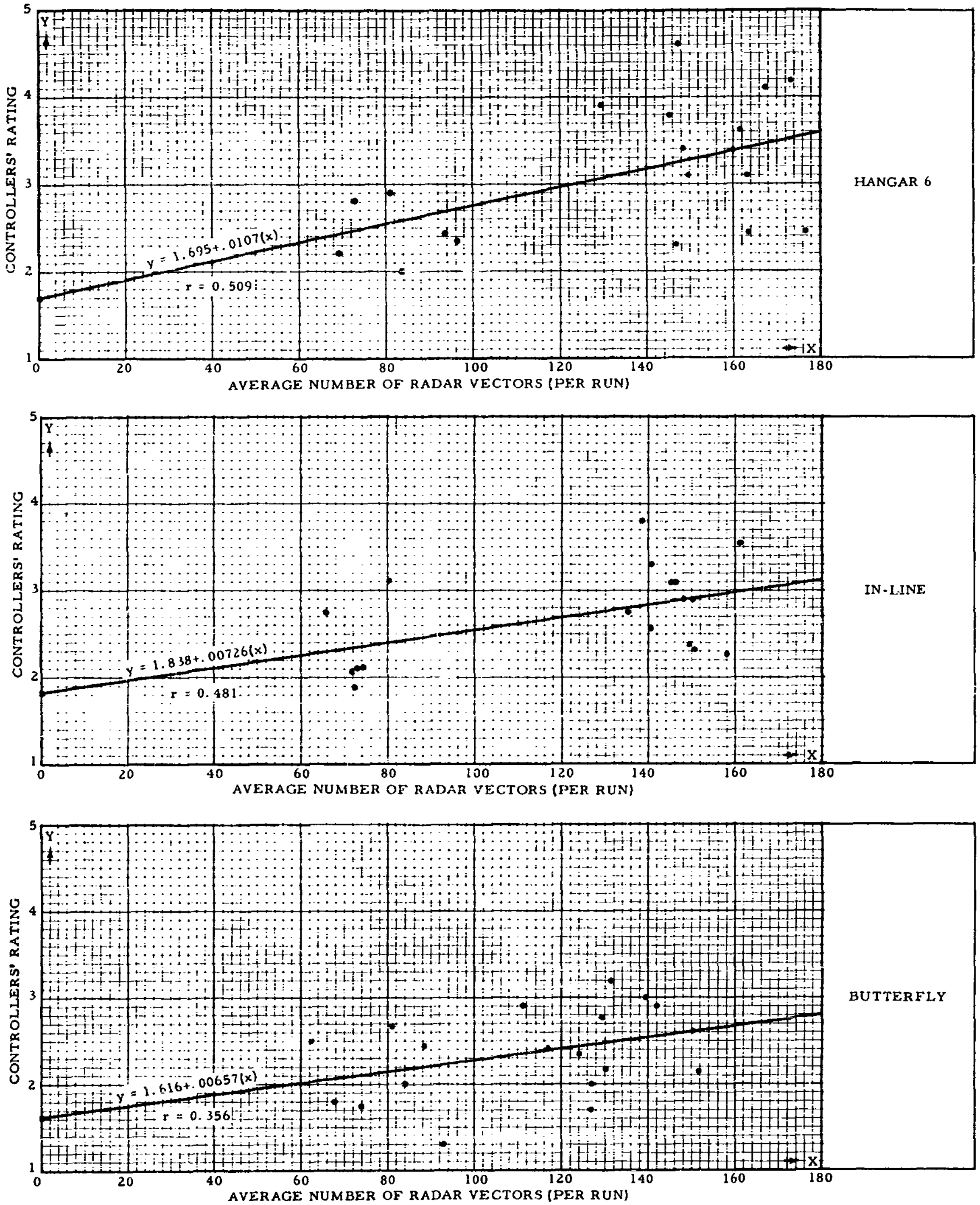


FIG. 52 COMPARISON OF RADAR-VECTOR COEFFICIENTS OF CORRELATION BETWEEN CONFIGURATIONS

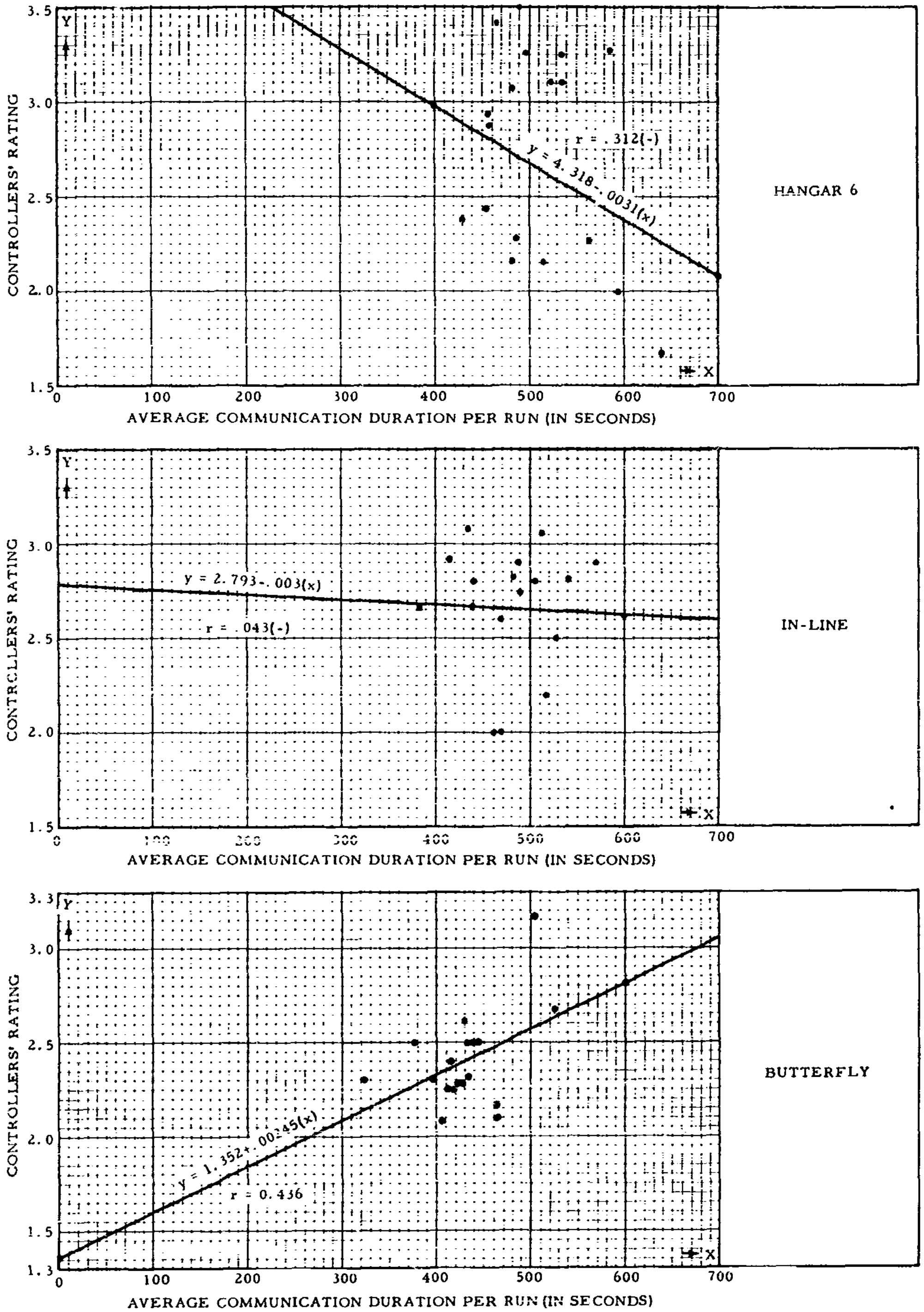


FIG. 53 COMPARISON OF DURATION OF COMMUNICATION COEFFICIENTS OF CORRELATION BETWEEN CONFIGURATIONS

Figures 50, 51, 52, and 53 present a pictorial comparison between configurations of the different coefficients of correlation grouped by system performance measures. It is interesting to note that, in most cases, a small group of points always fall on the left-hand portion of the straight-line graph. These are the data from the Andrews controllers. It shows that, in most cases, their workload was lower than the other two airports and they rated themselves lower. The ideal coefficient-of-correlation curve in these cases would be at a 45° angle, with all the points falling on a straight line. These curves show a rather high dispersion and, therefore, a coefficient of correlation less than 1. 0.

Controller-Opinion Overall Average System Rating

The results of the analysis for this measure can be found in Tables V and VII. Referring to these results and the graphical presentation of the results in Fig. 54, the controllers did indicate significantly different preferences for the equipment configurations. In this measure, the small numerical value on the rating scale of 1 to 7 was the best rating. Therefore, in the controllers' opinion, the configurations were ranked in the following order: (1) Butterfly, (2) Hangar 6, and (3) In-Line.

In the case of the phases, the controllers felt that the climb corridor made little or no difference in simulating the problem.

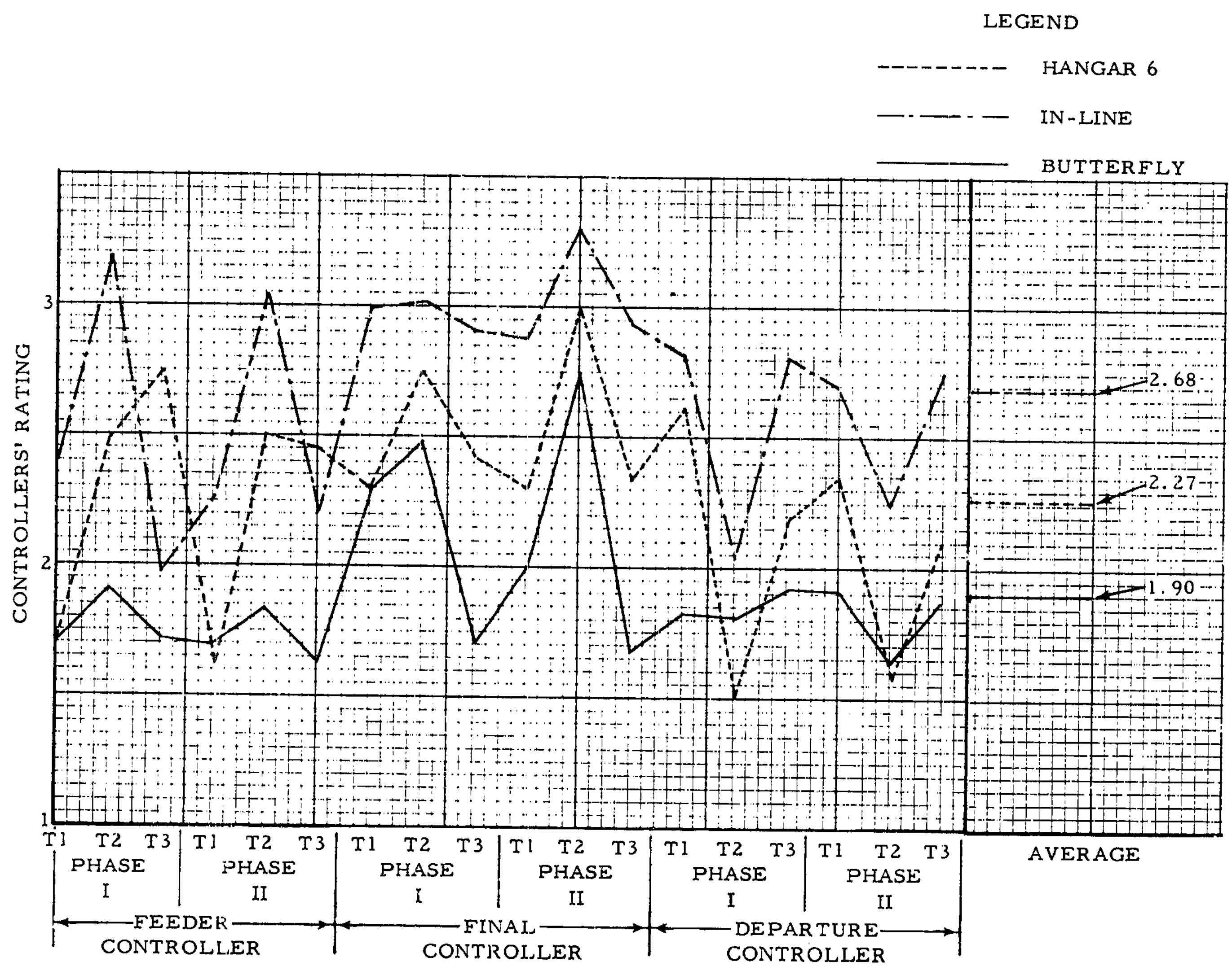


FIG. 54 CONTROLLER OVERALL RATING OF THREE SYSTEMS

Controller Opinion

Controllers, on a random basis, were asked to fill out a narrative-type questionnaire (Appendix V). This questionnaire was used to obtain controller opinions and recommendations in regard to the various equipment configurations, operating procedures, and the procedural plan.

These opinions indicated that the In-Line equipment configuration was the most difficult operation. This was evidenced by the physical location of the operating positions which brought about difficulties in coordination.

For ease of operation, the Butterfly and Hangar 6 equipment configurations were almost equally divided. The controllers cited the same reasons: operating positions located in such a manner as to bring about ease of coordination while still providing adequate work space.

Following are samples of controller comments taken at random from the narrative controller questionnaires:

1. Handoffs, both arrival and departure, are easily accomplished.

2. Insufficient airspace east of Washington to blend DCA and ADW departures effectively.

3. Charles Town and Gaithersburg too close to their respective airports as handoff points in a south operation, with Glen Ora the same in a north operation.

4. Martinsburg too close for a handoff point on a south operation.

5. V123 and jet penetration area of the BAL VOR are too close together.

6. Noise level much too high in In-Line equipment configuration.

7. Noise level and work area best in Butterfly configuration.

MISCELLANEOUS TESTS AND RESULTS

During the three-week exploratory period prior to data runs, and again at their completion, several runs were made to explore and evaluate different methods of control with respect to various facets of the simulation. During the data runs, some variations to the methodology were proposed, which were tested at the completion of these runs.

Radar Outages

Runs were made which simulated radar outages by shutting off both Airport Surveillance Radar (ASR) and Air Route Surveillance Radar (ARSR) scopes individually and in a random manner. This was done in an effort to see if the terminal control could effectively handle its traffic by working off ARSR scopes and, conversely, to see if the en route control could utilize ASR scopes for its traffic during these limited times. No adverse effects were experienced as all controllers who lost radar handled their traffic easily through reference to the other radar system. Radar outages which would dictate an ANC operation were not simulated because the procedural plan did not lend itself to this, as complete ANC route structures were not provided.

Saturated Clearance Limits

Several runs called for the preloading of traffic at the various clearance limits prior to the start of runs. There was no appreciable difference in the end result. Delay time was now charged to approach control rather than to the ARTCC.

Kent Island Traffic Landing Dulles Airport

Throughout all runs, the traffic sample included one aircraft destined for Dulles which was routed via V16 to Kent Island, in an effort to examine the attendant coordination required during the progression of this flight. The flight had to be handled by three transition controllers prior to handoff to the final controller. The coordination for altitudes and the related handoffs proved to be arduous and time-consuming.

Andrews Tests

Due to the large number of anticipated VFR proficiency flights to be generated by Andrews, nine exploratory runs were made to determine, if possible, the number of controllers and the type of radar equipment required to handle these flights. After consulting with the Andrews representative assigned to the planning team, a traffic sample consisting of 70 VFR arrivals plus 14 IFR arrivals was programmed for the one-hour-and-15-minute runs. The 84 flights were divided equally between jet and conventional-type aircraft, with all IFR aircraft making ILS approaches and 30 VFR aircraft, comprised of 15 jets and 15 conventional, making practice ILS approaches. Additional traffic departing Washington via V123S were programmed. With the volume of traffic programmed, two extra controllers were required to handle the VFR flights, one for jets and one for conventional-type aircraft. These two additional VFR controllers, referred to as VFR transition controllers, worked off ASR-4 type radar. They were responsible for identifying VFR traffic and vectoring it to the airport control zone (Fig. 55), providing radar separation until such time as the aircraft were under tower control. All VFR traffic (both jet and conventional) requesting clearance into the control zone, plus conventional traffic requesting practice approaches, called the appropriate VFR transition controller when approaching Tillman or Prince Frederick (Fig. 55), maintaining an altitude between 1500 and 5000 feet. The jet aircraft requesting practice penetration and ILS approaches called in over the appropriate approach fix (Baltimore, Brooke, and Patuxent River VOR's), depending on the direction of landing, at initial approach altitude. These VFR aircraft were commonly referred to as "pop-ups," and the area where they initially contacted the VFR transition controller was referred to as the "pop-up" area. When any of these aircraft requested practice instrument approaches, the VFR controller performed the necessary coordination with the IFR transition controller (either jet or conventional), and effected handoffs so that the IFR controller could sequence these aircraft with IFR traffic. The simulation of the Andrews proficiency flying was done under both a north and a south landing operation, using the Phase II route structure. Considering the volume of traffic handled, little difficulty was encountered. It was not possible to simulate the local control position, and VFR arrivals were discontinued at the control zone boundary. Therefore, the ability of the local controller to absorb this amount of traffic could not be determined.

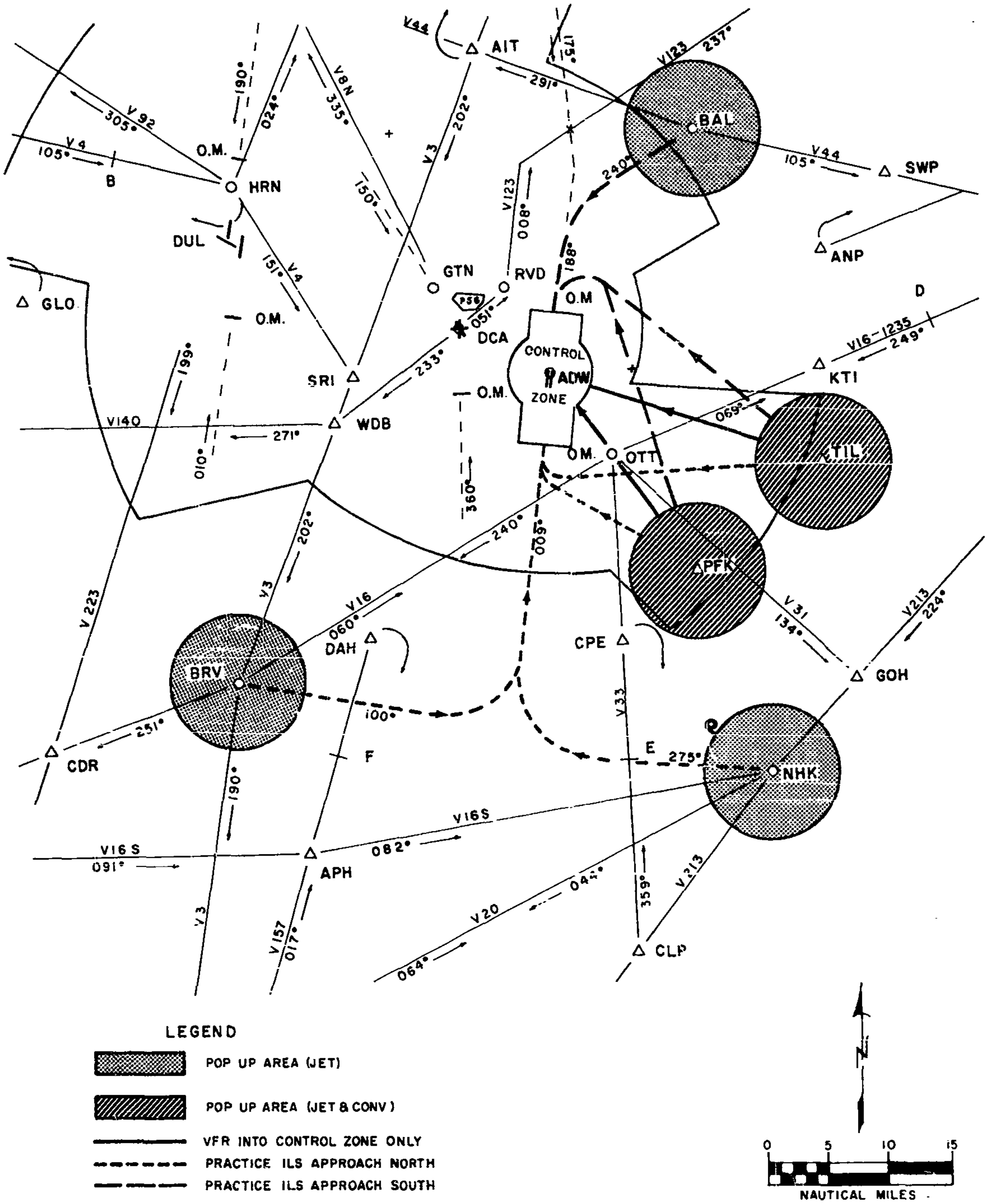


FIG. 55 ROUTES INTO CONTROL ZONE AND PRACTICE ILS APPROACHES AT ANDREWS AIR FORCE BASE

En Route Area Tests

During the last week of the dynamic simulation, 16 one-hour-and-15-minute runs were made to study the area between a 40- and 70-mile radius of the Washington Airport (Fig. 3). In testing the procedural plan and the three equipment configurations, it was assumed that the en route control function could meter traffic to supply the demands of the terminal facility. Another assumption was that the en route control could accept as many departures as the terminal facility could supply. Operating under these assumptions, , departures were flown only to a point at which they were no longer considered a control factor with regard to Metroplex arrivals and departures. Conversely, arrival aircraft were started at the outer edge of the transition area at relatively low altitudes. This point, in both arrivals and departures, was approximately 40 miles from the Washington Airport. The simulation of this area, beyond 40 miles, was a test to determine whether the en route control could meet these demands. The departure aircraft were started at the airports and the arrivals terminated at the outer marker.

Due to the added mileage to be flown and the consequent increase in flying time, target-generator availability was reduced to a point where it was possible to simulate only a portion of the Metroplex total activity. This traffic sample consisted of:

1. All Washington Airport arrivals and departures which were in the original traffic sample (36 arrivals and 30 departures per hour).

2. All Dulles Airport departures (30 aircraft per hour). The Dulles arrivals were not considered to be pertinent to this study.

3. The Andrews Airport aircraft that would arrive and depart over routes which were common to the Washington/Andrews operation (8 aircraft).

4. Six aircraft overflying the Metroplex area.

Eight runs were made on the Hangar 6 configuration and eight on the Butterfly configuration. The departures were climbed to cruise altitudes commensurate with the type of aircraft. The arrivals cruised at altitudes normally used in present-day operations. The en route traffic was programmed at times and altitudes which would introduce problems in both the climbing of departures and the descent of arrivals.

In the area simulated, which was primarily the west side of a north/south axis through the Washington Airport, it was decided that the airway which normally would be used for traffic overflying this portion of the Metroplex was Victor Airway 166. Since 10,000 feet was determined to be the lowest altitude available for overflights, random altitudes appropriate for the direction of flight were assigned from 10,000 through 18,000 feet. Three of these flights were westbounds and three were eastbounds.

The en route controller radar-identified this traffic entering the area, provided separation between arrivals and en route aircraft, gave descent instructions to arrival aircraft, began to effect a sequence of traffic, and accomplished radar handoffs to the transition controller. Speed control was not utilized by the en route controller unless requested by and/or coordinated with, the transition controller. In the event of faster aircraft overtaking slower aircraft, altitude separation or lateral spacing was effected. In order to comply with the en route requirements to meter traffic, it was sometimes necessary to control the flow of traffic by delaying maneuvers. Any delay was to be given prior to the handoff point.

The departures were handed off to the en route controller when aircraft were at cruising altitude and/or any possibility of confliction was eliminated. This handoff point varied slightly with the equipment configuration.

In the Butterfly configuration, the proximity of transition and en route controller positions made it feasible for the transition controller to retain control of his departure for a longer distance, if necessary, even to the boundary of the ARTCC area.

In the Hangar 6 configuration, the center controller must be controlling these aircraft prior to their entry into the center area of jurisdiction unless procedural restrictions are applied.

General controller opinion indicated that the en route operation would have no difficulty in meeting its requirements. The Butterfly configuration was favored because of the ease of coordination created by the proximity of the transition controller and his associated en route controller. Either could act as a buffer for the other, distributing the workload between them so that the possibility of one man becoming overloaded was reduced.

Andrews ADC Aircraft

During the nondata runs, several Andrews ADC scrambles were introduced in a random manner to determine if there would be any adverse effect on the normal flow of traffic. All scramble aircraft departed to the north, with an immediate right turn to the climb corridor. It appeared that, with the 5 minute scramble warning, the only noticeable effect was a slight delay to arrival aircraft landing south, which were in proximity to the outer marker at the time of scramble. This delay was a result of scramble aircraft departing in a direction opposed to the existing flow of traffic.

Civil Jet Descents

Near the end of the dynamic simulation, it was requested that a test be made to observe the operation involved in descending arrival jets at Dulles Airport. It was assumed that these jets would enter the Washington Center area at minimum flight levels (24,000 - 26,000 feet). The area in which the Washington Center is most restricted, due to the proximity of adjacent Center boundaries to approach fixes, is north and northwest of Martinsburg. The distance from Martinsburg to the boundary is 28 nautical miles. This area presented the greatest problem associated with descending aircraft from high altitudes to approach altitudes in a limited amount of time. For consistency, and in an effort to keep the operation at a maximum degree of difficulty, it was assumed that the adjacent Center could not accomplish any descent lower than the base flight level within their area. Airway V166 (Fig. 3) is considered to be an en route bypass airway, and IFR through traffic on this airway was restricted to assigned altitudes of 10,000 feet and above. Radar handoffs from the adjacent Center were a basic assumption. To effect an expeditious arrival at Dulles Airport, these jets would have to cross Charles Town at an altitude not in excess of 6000 feet. This altitude varied, depending on the direction of landing; when landing South, it conceivably could be 4000 feet. The traffic sample consisted of eight civil jet aircraft. These aircraft were assigned either 24,000 or 26,000 feet and were programmed to commence flight at a point 28 nautical miles northwest of Martinsburg at 1 minute intervals. All aircraft descended at maximum rate to Martinsburg and then reduced to approach speed. Table X shows the performance of each aircraft.

TABLE X

JET PERFORMANCE RESULTS

Entry	Type	Initial Altitude	Altitude Crossing MRB	Altitude 3-4 miles Northwest of Charles Town
1	DC-8	24,000	9,700	5,800
2	CV-880	26,000	10,500	(missing)
3	DC-8	26,000	8,700	4,800
4	B-707	24,000	(missing)	4,000
5	B-707	24,000	10,500	5,400
6	B-707	24,000	8,600	5,700
*7	DC-8	26,000	18,300	11,500
8	DC-8	26,000	10,400	(missing)

*Due to frequency congestion, entry No. 7 was given a late descent.

Every effort was made to give descent clearances as soon as communication was established. The limited amount of data indicates that, when this was accomplished, it still was doubtful that all aircraft could comply with the 9000-foot restriction crossing V166. In the case of entry No. 7, it appeared that any delay in issuing descent instructions would make it impossible. It was felt that, if an additional 30 miles of airspace was made available to the Washington Center in this area, descents could be accomplished with little or no difficulty. This additional airspace would not only give the controller more latitude where he issued descent clearances, but also would insure that these aircraft would reach a lower altitude in the vicinity of Charles Town, thereby eliminating the possibility of any aircraft having to lose altitude by holding.

Preferential Arrival Route Change

During the period when the procedural plan was being dynamically simulated and developed to its optimum structure, the question arose as to the impact on the system if the New York-to-Washington traffic were routed so as to enter the Washington Metroplex area via V16, as opposed to the V3 routing. The traffic sample was modified to the extent that traffic originally programmed to arrive via V3 to Gaithersburg was reprogrammed to arrive via V16 to Kent Island. One run was made in a south operation and one in a north operation.

General controller comments were to the effect that the increased traffic at Kent Island merely amplified the controller workload at this clearance limit. This was evidenced through the additional coordination by transition controllers, due to traffic traversing the areas entailing handoffs which were not necessary in the V3 routing. If this routing were adopted, it probably would not benefit the system in any way and might result in the Washington Center controllers having to reroute this traffic.

At the time of these runs, Phase II of the procedural plan had not been developed. It is reasonable to assume that the elimination of the Andrews climb corridor may have made this routing more workable, at least in a south operation. It might be noted that this routing also increased the amount of traffic not destined for Andrews passing over Andrews Airport. Due to the limited amount of runs, no other observations were made. Further simulation would be necessary to determine if this routing could be accomplished with a minimum amount of controller effort.

CONCLUSIONS

The following conclusions were derived from the results of simulation studies and evaluation of the proposed and modified procedural plan and equipment configurations:

1. The original proposed procedural plan required modification.

2. The modifications of the plan and equipment configurations resulting from the simulation studies alleviated exposed problem areas.

3. The deletion of the Andrews climb corridor allowed for the inclusion of V123S. This airway provided an additional egress to the New York area.

4. During a South operation at Washington National Airport an undesirable target clutter area was created by departure traffic using V8N mixing with traffic inbound to Georgetown.

5. The "Butterfly" equipment configuration was best suited for handoffs with Center sectors while still employing person-to-person coordination.

6. The "Hangar 6" equipment configuration had no apparent disadvantages with respect to intra-facility coordination.

7. The proposed "In-Line" equipment configuration precluded some of the desired shoulder-to-shoulder operation of related positions, which resulted in an increase of interphone-type coordination.

8. As a result of the extensive VFR proficiency aircraft flights simulated at Andrews, two VFR radar transition controllers were needed located adjacent to and in addition to the IFR controllers.

9. Altitude separation between V123 departures and Baltimore VOR jet penetrations was required until the departures intercepted the 237° radial of the Bel Air VOR unless radar separation was insured. For simulation purposes, the jets penetrated to 8000 feet and maintained this altitude until established inbound on the localizer course. The departures maintained altitudes not above 7000 feet until intercepting the 237° radial of Bel Air VOR.

10. Center metering provided for a smooth flow of arrival traffic which was controlled effectively by the terminal area controllers.

11. The area northwest of Washington to the Pittsburgh Air Route Traffic Control Center boundary was insufficient for the expeditious descent of Dulles arrival jets, especially at the higher altitude levels.

RECOMMENDATIONS

It is recommended that:

1. If the modified procedural plan is adopted, Center procedures be developed for flow control and metering into the Washington area.

2. An equipment configuration similar to the "Butterfly" be used if the IFR terminal control function is integrated at Leesburg, Va.

3. Approximately 30 miles of the Pittsburgh Center area north and northwest of Martinsburg be placed under the jurisdiction of the Washington Center to expedite jet descents to Dulles International Airport.

APPENDIX I

EASTERN REGION PROPOSED PROCEDURAL PLAN

PHASE I

The proposed procedural plan will geographically encompass Washington Nationa, Andrews AFB and Dulles International Airports. The proposed airway structure, as opposed to that which exists today, is shown in Fig. 1 and 2. The following is a listing of the airways associated with the procedural plan:

a. V213 from Kenton direct to Patuxent and Hopewell VOR/VORTAC facilities. This is intended as a three-level bypass structure to provide a through route for Boston-Miami operations.

b. New route V20 from Patuxent River direct to Flat Rock VOR/VORTAC. This route is intended to serve as a connecting segment for V213 to provide through service to Atlanta via V20 or to Western terminals served by V260.

c. V16 from Kenton direct to Nottingham, Brooke and Gordonsville VOR/VORTAC facilities. This route is intended to provide service only in the basic and intermediate altitudes to transition aircraft to and from the en route structures and the terminal area.

d. V44 from Price VHF Intersection via Baltimore and Martinsburg VOR/VORTAC facilities. This route is intended to provide service only in the basic and intermediate altitudes to transition aircraft to and from the en route structures and the terminal area.

e. V3 from West Chester via Westminster and Brooke VOR/VORTAC facilities. The northern segment of V3 will provide ingress from Idlewild, Newark and LaGuardia at altitudes of 7000 feet and above. Philadelphia, Washington National, and Baltimore low-altitude operations can be accomplished at altitudes of 6000 feet and below. The southern segment of V3 via Brooke VOR/VORTAC to Ashland VHF Intersection will provide southbound egress for Washington/Andrews departure traffic.

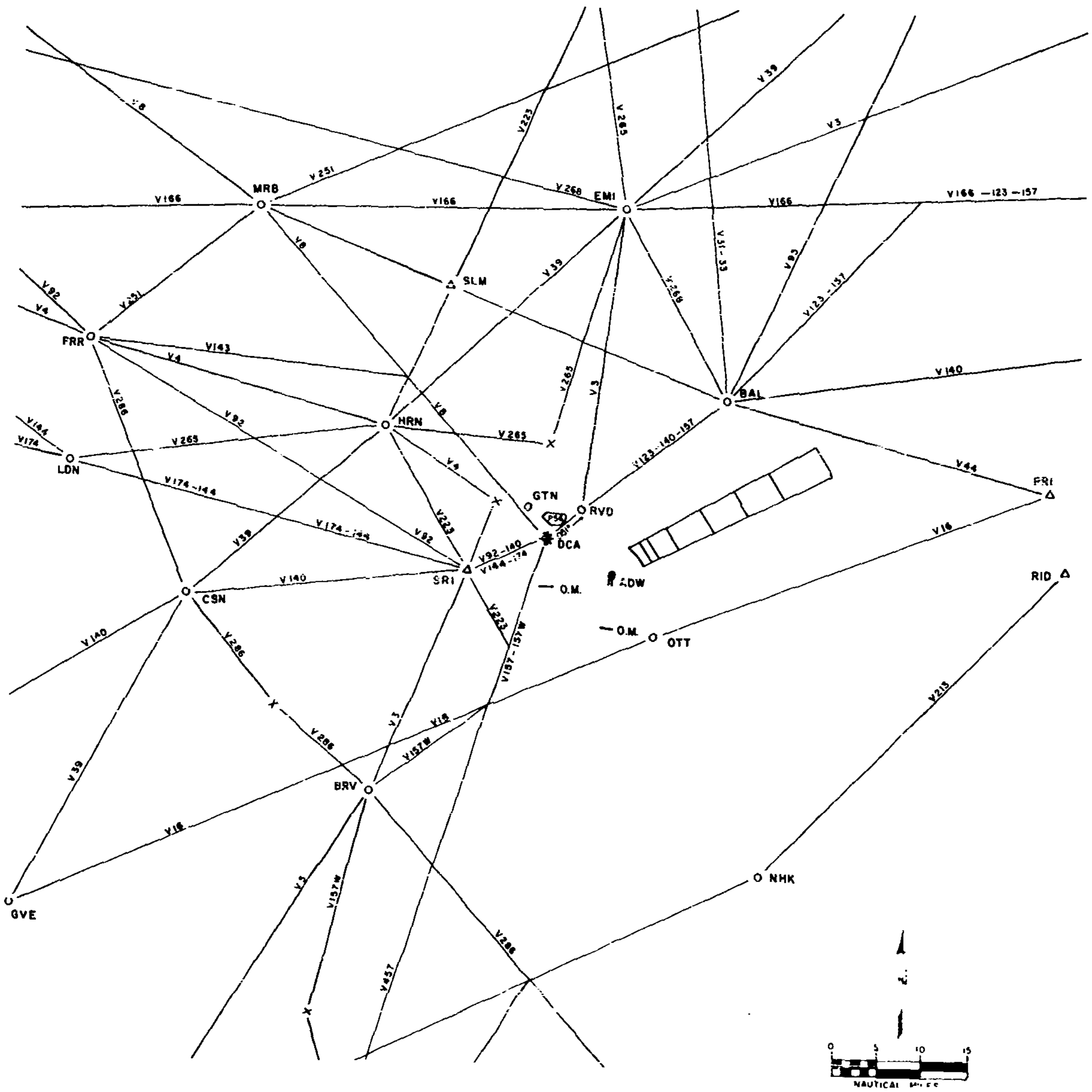


FIG. 1 PRESENT ROUTE STRUCTURE

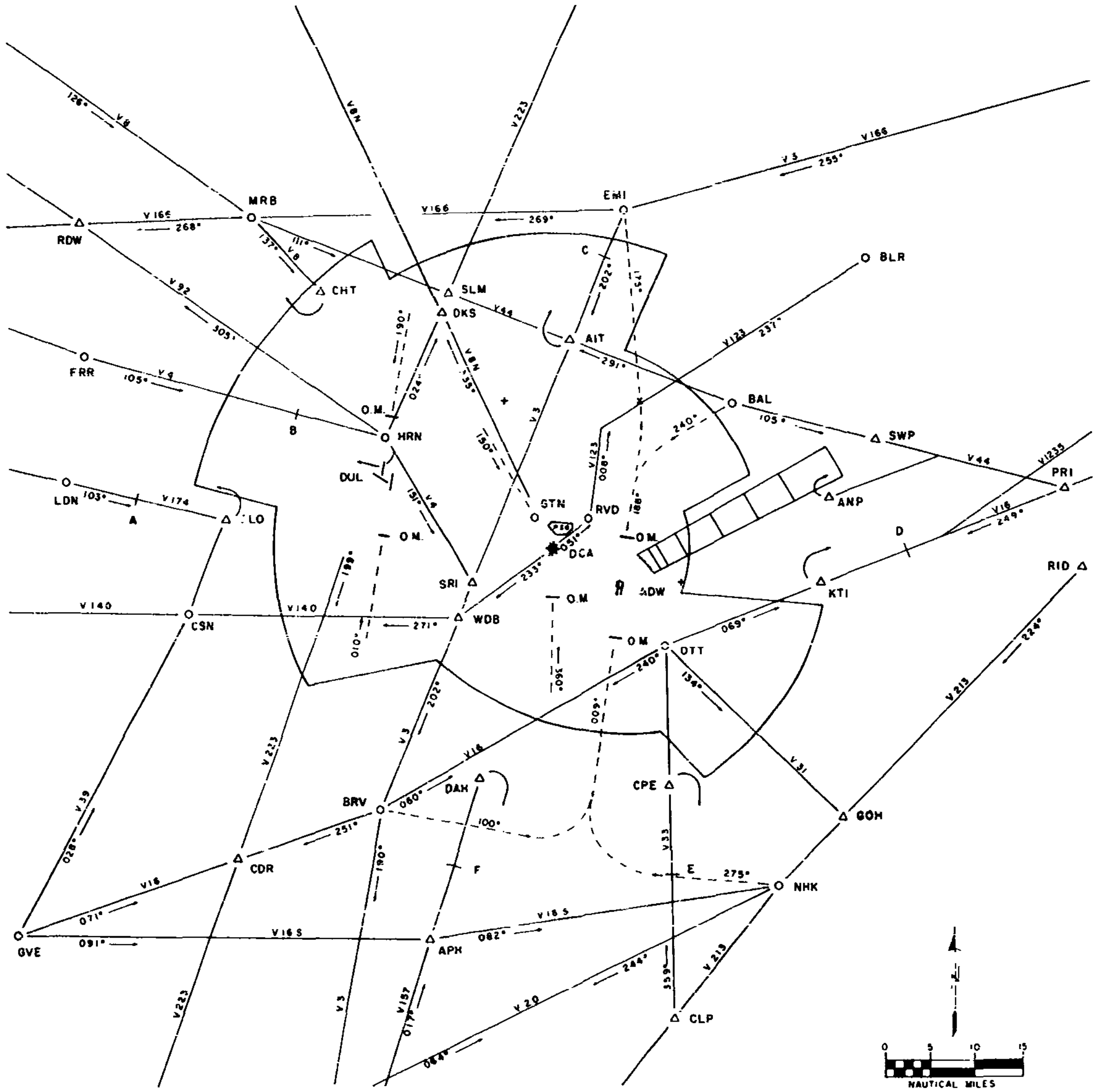


FIG. 2 PROPOSED ROUTE STRUCTURE

f. New route V166 from West Chester via Westminster, Martinsburg, and Kessel (new facility) to Elkins VOR/VORTAC facilities. This route is designed to serve intermediate and high altitudes and through traffic originating in the New York-Boston area destined for terminals located west of Washington, D. C.

g. V251 from Lancaster to Martinsburg to Kessel VOR/VORTAC facilities. This route is designed to transition through traffic in the intermediate structure and is a bidirectional route for traffic bypassing north of Washington, D. C.

h. New route V31 from Nottingham VOR/VORTAC to Golden Hill VHF intersection will serve as a primary departure route for Andrews AFB and secondary route for Washington National departures destined for Norfolk or Miami.

i. New route V33 from Nottingham VOR/VORTAC to Coles Point VHF intersection will serve as an arrival route to Andrews AFB only from V213.

j. V157 from Richmond to Washington VOR/VORTAC facilities. This will be utilized to serve northbound traffic destined for Washington National and Andrews AFB only.

k. New route V165 from Gordonsville VOR/VORTAC to A. P. Hill VHF Intersection to Patuxent River VOR/VORTAC will be utilized to serve inbound traffic destined for Washington National and Andrews AFB. This route is intended to provide bidirectional service in the intermediate structure and a bypass route for traffic proceeding south and southwest of Washington, D. C.

l. V223 from Harrisburg to Herndon to Flat Rock VOR/VORTAC facilities. A bidirectional route will accommodate transoceanic operations, using a great-circle route to the European continent. A considerable reduction in en route mileage can be achieved in international operations by using this route in preference to the coastal route structure (via V106-BOS).

m. New route V92 from Herndon to Grantsville VOR/VORTAC facilities. This route is designed to accommodate Dulles International departures destined for Pittsburgh, Cleveland, and Western terminals.

n. V39 Gordonsville to Casanova VOR/VORTAC facilities. This route would serve inbound traffic destined for Dulles International. V39 would terminate northbound at the Casanova VOR/VORTAC.

o. V140 (new route) Casanova, Spruce Knob (new facility) direct Elkins VOR/VORTAC facilities. This outbound route would serve traffic in the basic and intermediate structure departing Dulles International, Washington National, and Andrews AFB destined for west and northwest terminals.

p. V174 Elkins, Lindon, and Springfield. This route would provide ingress for traffic destined for Washington National and Andrews AFB from the west and northwest.

q. V8N (new route) Washington to St. Thomas VOR/VORTAC facilities. This route would provide egress for aircraft departing Washington National and Andrews AFB destined for Pittsburgh and Cleveland areas.

r. V123 (new route) Riverdale Beacon, thence a heading of 008° until intercepting the 237° radial of Bel Air VOR/VORTAC (new facility). This route would provide egress for traffic departing Washington National and Andrews AFB destined for Newark and LaGuardia areas.

s. V4 Elkins, Kessel, and Front Royal to Herndon VOR/VORTAC facilities. This route would provide ingress for traffic destined for Washington National and Andrews AFB from the west.

PROCEDURAL PLAN - OPERATIONAL PROCEDURES

PHASE I

A. DULLES INTERNATIONAL ARRIVAL CONTROL

a. Direction of Approach - All fields NORTH or
All fields SOUTH

CLEARANCE LIMIT	ROUTE	ALTITUDE	RADAR HANDOFF
CHARLES TOWN	V8	5000 (N)	NW edge TSO
		3000 (S)	NW edge TSO
GLEN ORA	V174, V39	4000 (N)	W edge TSO/CSN
		5000 (S)	W edge TSO/CSN

DULLES INTERNATIONAL DEPARTURE CONTROL

a. Direction of Takeoff - All fields NORTH or
All fields SOUTH

CLEARANCE LIMIT	ROUTE	ALTITUDE	RESTRICTIONS
Destination airport via		5000 (N)	5000/V8N (N)
SUGAR LOAF VHF INT.	V223	5000 (S)	4000/V4 (S)
Destination airport via		5000 (N)	5000/V140 (N)
CEDAR RUN VHF INT.	V223, V16	5000 (S)	5000/V140 (S)
Destination airport via		6000 (N)	6000/V4 (N)
RIDGEWAY VHF INT.	V92, V166	4000 (S)	6000/V4 (S)

B. WASHINGTON/ANDREWS AFB ARRIVAL CONTROL

a. Direction of Approach - All fields NORTH or
All fields SOUTH

CLEARANCE LIMIT	ROUTE	ALTITUDE	RADAR HANDOFF
GAITHERSBURG	V3	5000 (N)	N edge TSO
		5000 (S)	
KENT ISLAND	V16	5000 (N)	NE edge TSO
		5000 (S)	

CLEARANCE LIMIT	ROUTE	ALTITUDE	RADAR HANDOFF
*CHESAPEAKE	V33	4000 (N) 5000 (S)	S edge TSO

A. DULLES INTERNATIONAL ARRIVAL CONTROL

a. Direction of Approach - Dulles International South and Washington/Andrews AFB North

CLEARANCE LIMIT	ROUTE	ALTITUDE	RADAR HANDOFF
CHARLES TOWN	V8	3000	NW edge TSO
GLEN ORA	V174, V39	5000	W edge TSO/CSN

DULLES INTERNATIONAL DEPARTURE CONTROL

a. Direction of Takeoff - Dulles International South and Washington/Andrews AFB North

CLEARANCE LIMIT	ROUTE	ALTITUDE	RESTRICTIONS
SUGAR LOAF VHF INT.	V223	5000	5000/V8N
CEDAR RUN VHF INT.	V223, V16	5000	5000/V140
RIDGEWAY VHF INT.	V92, V166	6000	6000/V4

A. DULLES INTERNATIONAL ARRIVAL CONTROL

a. Direction of approach - Dulles International North and Washington/Andrews AFB South

CLEARANCE LIMIT	ROUTE	ALTITUDE	RADAR HANDOFF
CHARLES TOWN	V8	5000	NW edge TSO
GLEN ORA	V174, V39	4000	W edge TSO/CSN

DULLES DEPARTURE CONTROL

a. Direction of Takeoff - Dulles International North and Washington/Andrew AFB South

*Primary ANDREWS AFB - Secondary WASHINGTON NATIONAL

CLEARANCE LIMIT	ROUTE	ALTITUDE	RESTRICTIONS
SUGAR LOAF VHF INT.	V223	5000	4000/V4
CEDAR RUN VHF INT.	V223, V16	5000	4000/SV4 5000/V140
RIDGEWAY VHF INT.	V92, V166	6000	4000/HRN TSO 6000/V4

B. WASHINGTON/ANDREWS AFB ARRIVAL CONTROL

a. Direction of Approach - All fields NORTH or SOUTH

CLEARANCE LIMIT	ROUTE	ALTITUDE	RADAR HANDOFF
DAHLGREN	V157	5000 (N) 5000 (S)	S edge TSO
HERNDON	V4	7000 (N) *5000 (S)	W edge TSO

*Descend 7000 to 5000 in Herndon TSO

WASHINGTON DEPARTURES

a. Direction of Takeoff - All fields NORTH or SOUTH

CLEARANCE LIMIT	ROUTE	ALTITUDE	RESTRICTIONS
Destination airport via BAL VOR/BEL AIR VHF INT.	V123/V16, V31	5000 (N) 5000 (S)	4000 or BLO 338 OTT 4000 or ABV 338 OTT
Destination airport via WOODBRIDGE VHF INT.	V140, V3, V16	4000	4000/WOODBRIDGE
Destination airport via SUGAR LOAF VHF INT.	V8N, V223	4000	4000/GTN VHF INT. X SLM VHF INT. 6000 or ABV (N) X WASHINGTON VOR 4000 (S)

C. ANDREWS AFB JET ARRIVALS

a. Direction of Approach to the NORTH

CLEARANCE LIMIT	ROUTE	ALTITUDE	RADAR HANDOFF
BRV VOR	As assigned	20,000	5 min/BRV VOR
NHK VOR	As assigned	20,000	5 min/NHK VOR
BAL VOR Direction of Approach to the SOUTH	As assigned	20,000	5 min/BAL VOR

JET PENETRATIONS

Jet Penetration BRV VOR to ADW

DPT 100 BRV VOR 20,000 START IMDT DESCENT TO 13,000 AND LEFT TURN 190 ADW TO INTERCEPT 009 INBND ADW VOR CONTINUE DESCENT SO AS TO ARRIVE 16 NM SOUTH OF ADW @ 4000

Jet Penetration NHK VOR to ADW

DPRT 275 NHK VOR 20,000/174 ADW START DESCENT AND RIGHT TURN TO 009 INBND ADW VOR CONTINUE DESCENT SO AS TO ARRIVE 16 NM SOUTH OF ADW @ 4000

Jet Penetration BAL VOR to ADW

DPRT 240 BAL VOR @ 20,000 START DESCENT TO 8000 AND LEFT TURN TO INTERCEPT LOCALIZER COURSE CONTINUE DESCENT WHEN ON LOCALIZER COURSE TO 2500

ANDREWS AFB DEPARTURES

a. Direction of Takeoff - All fields NORTH or SOUTH

CLEARANCE LIMIT	ROUTE	ALTITUDE	RESTRICTIONS
Destination airport via BAL VOR	V123	As assigned	Cross BAL VOR 5000/AB
Destination airport via SWAN POINT	V44 V16 V44 V16/ Direct BEL AIR VOR	As assigned(N) As assigned(S)	None (N) None (S)

CLEARANCE LIMIT	ROUTE	ALTITUDE	RESTRICTIONS
Destination airport via GOLDEN HILL VHF INT.	V31	4000 (N) 4000 (S)	4000/SE of V16 (N) 4000/SE of V16 (S)
Destination airport via WOODBRIDGE VHF INT.	V140 V3 V16	4000 (N) 4000 (S)	4000/WOODBRIDGE INT. (N) 4000/WOODBRIDGE INT. (S)
Destination airport via SUGAR LOAF VHF INT.	V8N V223	4000 (N) 4000 (S)	4000/GTNX SLM 6000 or ABV (N) DCA VOR 4000 X SLM 6000 or ABV (S)
*Destination airport via BAL VOR/SWAN POINT VHF INT. NHK VOR	060 ADW VOR	As assigned	Cross BAL VOR 15,000 ABV Cross SWAN Pt 15,000 ABV Cross V16 13,000 or ABV

*Jet aircraft only

Clearance Limits and Holding Patterns (See Appendix III)

Fix	Direction of Holding	Direction of Turns	Size
Charles Town	Northwest 11NM MRB VOR/ 137 MRB VOR/020 CSN BOR/ 073 FRR VOR	Right	1 min.
Glen Ora	West 18 NM LDN/101 LDN VOR/020 CSN VOR	Left	1 min.
Gaithersburg	North 16NM EMI/202 EMI VOR/291 BAL VOR	Right	1 min.
Kent Island	Northeast 18NM OTT VOR/ 069 OTT VOR/155 BAL VOR	Right	1 min.
Chesapeake	South 15 NM OTT VOR/180 OTT VOR/084 BRV VOR	Right	1 min.
Dahlgren	South 26NM DCA VOR/196 DCA VOR/071 BRV VOR	Right	1 min.

Fix	Direction of Holding	Direction of Turns	Size
Herndon	West 285 HRN VOR	Right	1 min.
Annapolis	Northeast CHURCHILL VOR 248 CHR VOR/135 BAL VOR	Right	1 min.

APPENDIX II

WASHINGTON METROPLEX PROCEDURAL PLAN

PHASE II

This phase evolved from the changes proposed to Phase I. These changes are listed below and reflect the difference between the two phases.

1. Deletion of the Andrews AFB climb corridor.

2. Deletion of the Kent Island Intersection as a clearance limit.

3. Addition of V123S.

   a. The routing is the 109° radial of Andrews AFB VOR until intercepting the 069° radial Nottingham VOR, proceed outbound on that radial until intercepting the 235° radial of Woodstown VOR. This route would provide egress for traffic departing Washington/Andrews AFB destined for Newark and LaGuardia areas.

4. Addition of the Annapolis Intersection. It is made up of the 248° radial of Churchill VOR and the 135° radial of the Baltimore VOR. This clearance limit replaces Kent Island and is clear of V123S.

APPENDIX III

LOCATION IDENTIFIERS

ADW - Andrews Air Force Base

AIT - Gaithersburg

ANP - Annapolis

APH - A. P. Hill

ASH - Ashland

BAL - Baltimore

BLR - Bel Air

BRV - Brooke

CDR - Cedar Run

CHR - Churchill

CHT - Charles Town

CLP - Coles Point

CPE - Chesapeake

CSN - Casanova

DAH - Dahlgren

DCA - Washington National Airport

DKS - Dickerson

DUL - Dulles International Airport

ELK - Elkins

EMI - Westminster

ESR - West Chester

FAK - Flat Rock

FRR - Front Royal

GLO - Glen Ora

GOH - Golden Hill

GRV - Grantsville

GTN - Georgetown

GVE - Gordonsville

HRN - Herndon

KSL - Kessel

KTI - Kent Island

LDN - Linden

MRB - Martinsburg

NHK - Patuxent River

OTT - Nottingham

PRI - Price

RDW - Ridgeway

RIC - Richmond

RVD - Riverdalc

SLM - Sugar Loaf

SWP - Swan Point

WDB - Woodbridge

APPENDIX IV

CONTROLLER RATING-SCALE QUESTIONNAIRE

WASHINGTON METROPLEX

Name ____________________ Date ____________________

Position ____________________ Run No. ____________________

Wind Condition ____________

A. Communication

1. For each of the following, indicate your estimate of the LEVEL of coordination:

	Light					Heavy		N/A
A. With Center controller	1	2	3	4	5	6	7	☐
B. With transition controller	1	2	3	4	5	6	7	☐
C. With feeder controller	1	2	3	4	5	6	7	☐
D. With departure controller	1	2	3	4	5	6	7	☐
E. With tower/approach cont.								
(1) at DCA	1	2	3	4	5	6	7	☐
(2) at ADW	1	2	3	4	5	6	7	☐
(3) at Dulles	1	2	3	4	5	6	7	☐

2. Indicate your estimate of the EASE of coordination:

	Light					Heavy		
A. With Center controller	1	2	3	4	5	6	7	☐
B. With transition controller	1	2	3	4	5	6	7	☐
C. With feeder controller	1	2	3	4	5	6	7	☐
D. With departure controller	1	2	3	4	5	6	7	☐

E. With tower/approach cont.

	Light					Heavy		N/A
(1) at DCA	1	2	3	4	5	6	7	☐
(2) at ADW	1	2	3	4	5	6	7	☐
(3) At Dulles	1	2	3	4	5	6	7	☐

B. Holding at feeder fix

1. The work load providing altitude changes for separation of aircraft while holding at a fix was:

Light					Heavy		
1	2	3	4	5	6	7	☐

2. The work load for the number of aircraft held at the feeder fix was:

Light					Heavy		
1	2	3	4	5	6	7	☐

C. Number of radar vectors

1. The work load providing radar vectors for separation (conflict avoidance) was:

Light					Heavy		
1	2	3	4	5	6	7	☐

2. The work load providing radar vectors for guidance and interval was:

Light					Heavy		
1	2	3	4	5	6	7	☐

D. Number of altitude changes

1. The work load providing altitude changes for separation (conflict avoidance) was:

Light					Heavy		
1	2	3	4	5	6	7	☐

2. The work load providing altitude changes between feeder fix and outer marker was:

Light					Heavy		
1	2	3	4	5	6	7	☐

E. Speed control

1. Speed control was used after reaching the feeder fix: (circle one) All of the Time Some of the Time Not used

2. Speed control was used for departures: (circle one)

All of the Time Some of the Time Not used

F. Controller functions

	Light					Heavy		N/A
1. Controller work load for radio communications was:	1	2	3	4	5	6	7	☐
2. Controller work load for inter-phone communications was:	1	2	3	4	5	6	7	☐
3. Controller work load for inter-phone communications was:	1	2	3	4	5	6	7	☐
4. Controller work load for altitude changes was:	1	2	3	4	5	6	7	☐
5. Controller work load for speed changes was:	1	2	3	4	5	6	7	☐
	Adequate					Inadequate		
6. The relative physical position of the controller was:	1	2	3	4	5	6	7	☐
7. Equipment lay out was:	1	2	3	4	5	6	7	☐
8. Area of work space was:	1	2	3	4	5	6	7	☐

G. Safety

1. Potential hazardous areas existed: Yes No

   If yes, where? ____________________ Why? ____________________

H. Coordination

	Light					Heavy	N/A
1. The amount of verbal coordination across or between scope (s) (not on interphone) was:	1	2	3	4	5	6	7	☐

2. The heaviest coordination was with ____________________
   Position

   which was accomplished by: (circle one)

   Interphone Personal Contact Coordination Man

3. The next heaviest coordination was with ____________________
   Position

   which was accomplished by: (circle one)

   Interphone Personal Contact Coordination Man

APPENDIX V

CONTROLLER NARRATIVE QUESTIONNAIRE

Your cooperation is requested in completing the following questionnaire to help evaluate the plans tested

PLAN OR PHASE #__________

DATE____________________

NAME____________________

POSITIONS WORKED IN THIS PHASE OR PLAN:__________

____

1. Coordination was (heavy, moderate or light) with the center: ________, with the towers: ________, within the facility: __________.

   Coordination was (easy, moderately easy or awkward) with the center: ________, with the towers: ________, within the facility: __________.

   General comments on coordination: ____________________

   ____

   ____

2. General comments on communications: (noise level, channel loading, accessibility, etc.).

   Radio: ____________________________________

   ____

   ____

Interphone: ____

____

____

Hot Lines: ____

____

____

3. General comments pertinent to the radar displays: (equipment location or layout, retention of radar identification, work areas and space, etc.)

____

____

____

____

____

____

4. General comments pertinent to control and flight data positions of responsibility, locations of positions of operation, division of control workload, and radar handoffs both inbound and outbound:

____

____

____

____

____

____

5. General comments on conflictions or potentially hazardous conditions:

Did you have any conflictions? (yes/no)

6. General comments regarding the use and/or location of navigational aids, fix locations, need for more or less video mapping, location of approach gates, etc:

7. Of the plans tested to date, which one do you prefer?

Why?

Please use the space below for your comments on any of the eight items of this questionnaire if more space is required. If you have any other comments or suggestions not covered in this questionnaire, please indicate below.

Item #______

Item #______

Item #______

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